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FIXATION OF FRACTURES IN THE MIDDLE THIRD OF THE FACE, WITH KIRSCHNER WIRES.*†

HERBERT H. HARRIS, M.D.,

Houston, Tex.

There is an ever increasing number of fractures about the body as a result of violence, most of which are caused by traffic accidents. Many of these are about the head and face, and not infrequently of the middle third. Though fractures in the middle third of the face may be the only or principal injury, they do occur with other fractures, such as the mandible or long bones of the body, and many times with severe skull or brain injury.

When fractures of the middle third of the face do occur with other injuries the picture is more complicated, and the other injuries may be of primary concern. It is because of these severe injuries that facial fractures may either go unnoticed or ignored until late, enough so at times to make their primary reduction impossible.

There are many things which must be taken into consideration before a fracture in the middle third of the face is reduced. Severe or critical injury elsewhere may prevent the early reduction of these fractures; in fact, unless I can get them rather early, four or five or even ten days' delay seems to make little difference in the reduction, and with the use of antibiotics infection is no longer a hazard. Even at the end

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†From the Department of Otolaryngology, Baylor University College of Medicine.

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of four weeks I have been able to reduce some of these fractures, for they heal by scar tissue, and at this time one can reduce them with some difficulty, mobilize the fragments for better alignment, but when there are small comminuted areas it is most difficult to replace these small fragments.

The primary objective when a patient has these, combined with other severe injuries, is to preserve the life of the patient, since in themselves these fractures are rarely serious. Shock, severe brain damage, chest and abdominal injuries must be treated first. Hemorrhage from the broken blood vessels along the line of fracture is one complication which must be controlled early, regardless of the severity of injuries elsewhere. Most bleeding can be controlled by packing the nose when such fractures extend through the nasal cavities, although other means must be resorted to when necessary.

Airway obstruction may follow some severe injuries and a tracheotomy should be done without hesitation. When lacerations of the face do occur in combination with these fractures they should be meticulously repaired early, even if it is impossible to reduce the fractures at the same time. If the fracture is to be reduced within the first 24 hours, I recommend that the fracture be reduced first and the laceration repaired last; for sometimes in manipulation, the lacerated areas may be separated, and a good cosmetic result cannot be obtained.

There are several anatomical landmarks which must be kept in mind as a guide to obtain the best result; the nasal bones, the infraorbital ridge, the malar eminence of the zygomatic bone and the occlusion of the teeth. Of course, all of these may not be involved in every fracture, but they all must be restored to the original position if good function and good cosmetic results are obtained. Even though the alveolar ridge with the upper teeth may not be involved, fractures of the zygoma, the infraorbital ridge and the floor of the orbit may allow the eye to dip so that diplopia develops and even trismus due to the impingement of the coronoid process on the zygoma. Fractures of the nasal bones, with displacement, may cause nasal obstruction and fractures

about the lacrimal bone and the lacrimal duct may cause tearing of the eye.

The diagnosis of facial fractures is usually not difficult for one who is familiar with the landmarks. Tactile sense of the trained index and middle fingers can always elicit deformity regardless of the swelling, unless infection has taken place and the tissues have become brawny. As mentioned before, palpation of the nasal bones, the infraorbital ridge, the malar eminence of the zygomatic bones and the occlusion of the teeth are the points which, if in their proper position, almost always means either no fracture or displacement of the fractured bones.

There are many positions for taking X-ray to determine the extent and location of fractures in this area, but due to the thinness of some of the bones and shadows cast by overlying bone I have never been satisfied with flat plates. Usually, and I might say always, a good stereo in the Waters position studied thoroughly will give not only a clear picture of the nature and extent, but also will tell one the direction of the force which caused the fracture. This is always very important to me, as a force for traction in the opposite direction to that causing the injury must be exerted to reduce the fracture.

There are many methods of reducing fractures of the zygoma, as there are many methods used to fix other fractures. I do not believe that one can use any one method for all facial fractures any more than one method only can be used for fixing fractures of long bones. Open reduction and wiring of the fragments has its advantages as well as its disadvantages. Packing a sinus to reduce a fracture of the infraorbital ridge and anterior wall of a sinus, when the zygomatic bone has been fractured and pushed into the sinus, is not always enough to insure good results. The use of the Kirschner wire as a method of fixation is not the method I use in every case, but I do believe that it is the simplest and the most satisfactory when combined with other methods if necessary.

The Kirschner wire (see Fig. 1a) much like the Steinman

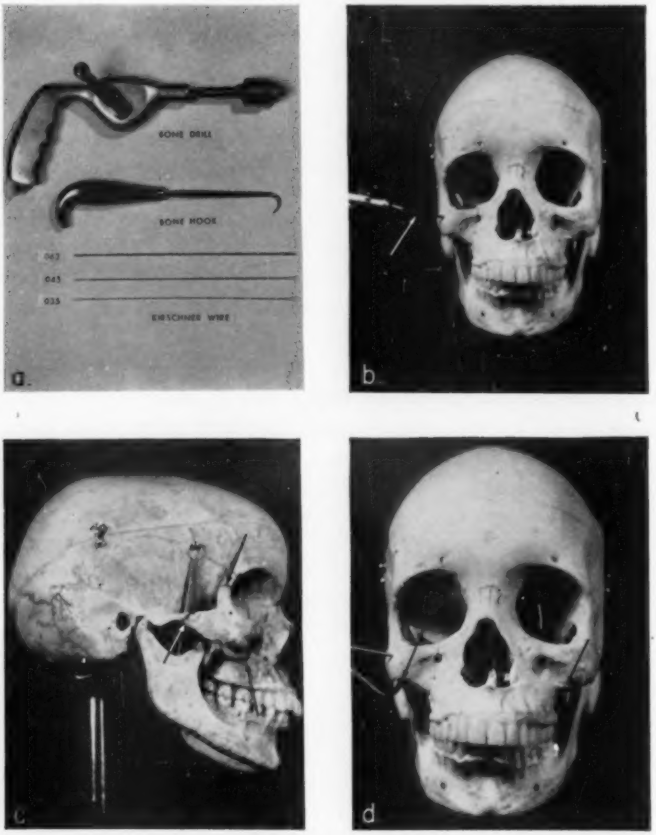

Fig. 1a. Ordinary bone drill, bone hook and the three sizes of Kirschner wires.

Fig. 1b. Only about 1½ to 2 inches of the wire are allowed to remain between the bone and the chuck of the drill to preevnt wobbling.

Fig. 1c. Fracture lines in simple zygomatic fracture.

Fig. 1d. Shows the position of the bone hook to reduce a typical zygomatic fracture and the direction of the Kirschner wire into the other side.

pin but smaller comes in three sizes; .062, .045, and .035 of an inch, is made of stainless steel and can be drilled into the bone or through the bone without first making an opening. Ipsen[3] described the use of the Kirschner wire in fixing fractures of the mandible in 1933. Brown, et al.,[1,2] reported its use first in 1951 for fractures in the middle third of the face. There is one important point to remember in using the wire. If a drill especially made for the Kirschner wire is not available, any hollow shaft drill can be used, but only about one-and-one-half to two inches of the wire should be allowed to extend beyond the end of the chuck (see Fig. 1b). Allowing such a small amount of the wire to extend beyond the chuck prevents wobbling of the wire, and the direction of the drilled wire is more accurate. In most facial fractures I have found the .062 or the heavy Kirschner wire to be the most satisfactory size.

Though fractures may occur with much comminution, there are several which I believe rather completely typify most of these fractures of the middle third of the face. Probably the most common injury is that to the nose and the frontal processes of the maxilla. I shall not take this up in my discussion except insofar as it is related to other fractures in this region.

Though no two fractures are alike, most are similar in that they may be classified into six general types:

1. Simple zygomatic fractures.

2. Zygomatic fractures with comminution of the infraorbital ridge and anterior wall of the sinus.

3. Transverse fractures of the maxillae or LeFort I.

4. Pyramidal fractures of the maxillae or LeFort II.

5. Cranio-facial fractures of LeFort III.

6. Combination of some of the above with comminutions.

Simple zygomatic fractures not infrequently may be reduced with the bone hook or some other device such as a towel clip, though occasionally I have been unable to reduce the fracture without entering the maxillary sinus when there

seemed to be impaction of the fragments. I have not found it necessary to make an incision above the arch. The fracture lines in a simple zygomatic fracture (see Fig. 1c) usually occur in or near the suture line of the fronto-sphenoidal process with the corresponding bones, near the suture line in the zygomatic arch and through the anterior wall of the maxillary through the infraorbital foramen downward and laterally through the thin lateral wall of the maxilla.

A large percentage of these simple fractures when reduced will remain in good position without fixation. This depends materially on how much comminution there is at the fracture line. If the zygomatic bone does not remain in good position, it can be held in place with the bone hook and a .062 Kirschner wire drilled through the body of the fractured zygoma into the medial maxillary wall across the nose, through the medial wall and into the lateral wall of the opposite maxillary just below the body of the zygoma (see Fig. 1d). Formerly, I tried to drill the wire through to the opposite body of the zygoma, but this is not necessary as it does keep the wire away from the opposite orbit and the infraorbital nerve. I have never seen an accident occur with the wire, but I am sure it would be possible for the wire to be deflected into the opposite orbit if one were not very careful when trying to fix the wire into the opposite body of the zygoma. Passing through these several structures, the medial wall of both maxillary sinuses, the nasal septum and into the lateral wall of the opposite sinus, usually give sufficient support of the wire. If a satisfactory reduction and fixation is not accomplished at first the wire may be withdrawn. In difficult cases I have drilled it across to the opposite side as many as three or four times before getting a satisfactory position. I have never seen any untoward results as it punctures the turbinate and is withdrawn. There may be some bleeding which stops very quickly. A case of simple fracture of the zygoma is herewith illustrated (see Figs. 2a, 2b, 2c and 2d).

Comminuted fractures of the infraorbital margin and the anterior wall of the maxillary sinus, combined with a depression of the zygomatic bone into the sinus, poses a slightly greater problem in obtaining good results (see Figs. 2d, 3a

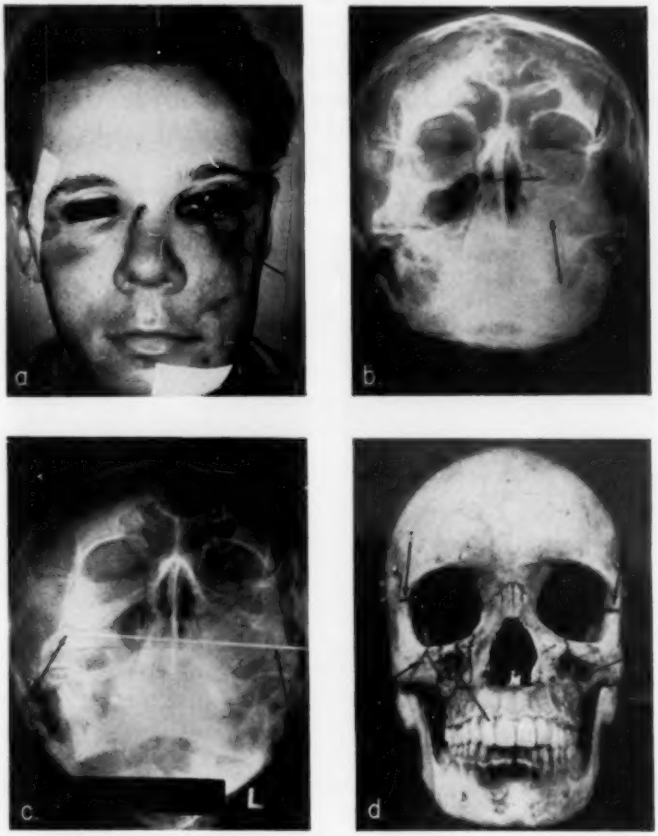

Fig. 2a. Typical depression over the cheek area in simple zygomatic fracture.

Fig. 2b. Typical fracture lines. Note the reduced size of the maxillary sinus due to the depressed zygoma.

Fig. 2c. Reduced fracture fixed with a Kirschner wire by fixing across to opposite zygoma.

Fig. 2d. Right zygoma shows typical fracture lines with comminution of the infraorbital margin and anterior maxillary wall through the zygomatic arch and the frontal-sphenoid suture line area. Left zygoma shows typical fracture lines of the simple zygomatic fracture.

and 3b). Entering the maxillary through the canine fossa region and making a counter opening into the inferior meatus for the purpose of removing the gauze packing is usually necessary. I pack the sinus with one-half inch gauze impregnated with aureomycin ointment and replace and mold the comminuted fragments back into place, and suture the wound, bringing the gauze out of the opening in the inferior meatus.

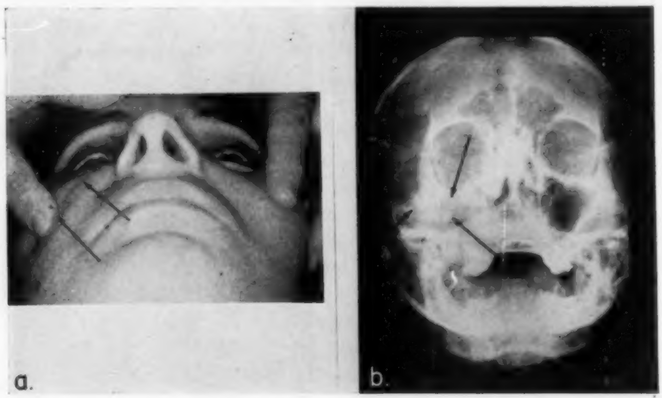

Fig. 3a. Typical appearance of the face in a fracture of the zygoma with comminution of the anterior wall of the sinus and the infroarbital margin.

Fig. 3b. X-ray findings of the same patient showing the comminutions when stereo was viewed.

The body of the zygoma, which usually is not comminuted, may be held in place as in a simple zygomatic fracture, passing the wire across the gauze filled cavity. Of course, the gauze must be left in as long as the wire, which I find is usually 18 to 21 days.

I wish now to take up the group of fractures known as the LeFort I, II and III, or the transverse, pyramidal and craniofacial features (see Figs. 4a, 4b,). These have one factor in common. The maxillae containing the teeth is fractured from the skull at different levels. The teeth, therefore, do not occlude normally or properly. Though the maxillae are

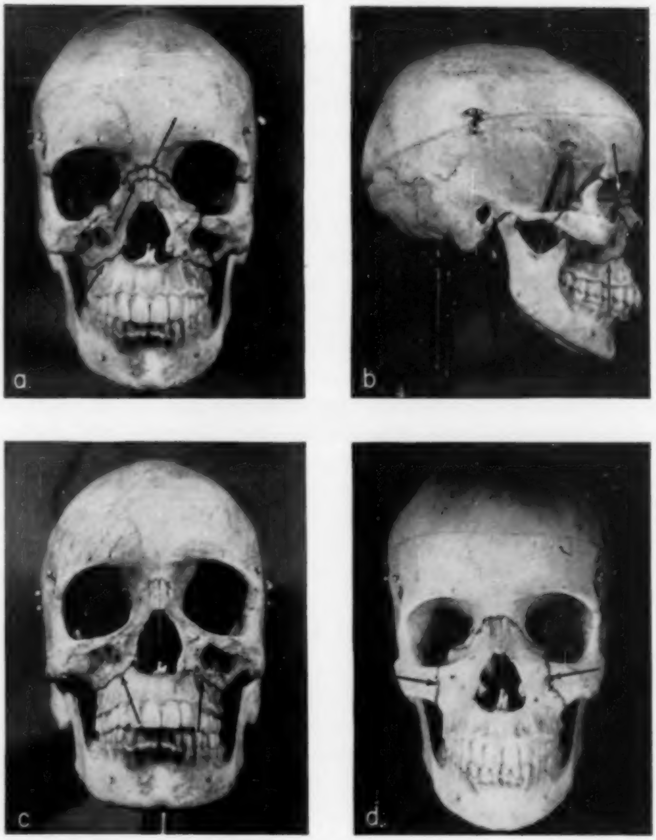

Fig. 4a. Typical lines of fracture, transverse, pyramidal and cranio-facial from below upward. Front view.

Fig. 4b. Same. Side view.

Fig. 4c. Fracture lines, transverse fracture of maxillae.

Fig. 4d. Fracture lines, pyramidal fracture of maxillae.

usually fractured downward and backward, occasionally the maxillae are pushed backward and upward.

The transverse fracture occurs just above the alveolar margin so that the teeth, if they are present, are contained in the lower fragment (see Fig. 4c). In my experience these are less common than the pyramidal, but likely occur when dentures are worn and the blow occurs over the dentures, causing a shearing injury.

Pyramidal fractures occur a little higher up on the maxillae involving the nasal bones, the anterior wall of the maxillae and the infraorbital ridges, the floor of the orbit and the anterior and lateral wall of the maxillae, usually at different levels on each side (see Fig 4d).

The cranio-facial fracture is at a still higher level through the ethmoid labyrinth into the posterior part of the inferior orbital fissure, near the suture line between the fronto-sphenoidal process with the corresponding bones and through the zygomatic arch (see Fig. 5a). To secure and maintain proper occlusion of the teeth is one main objective. If no teeth are present occlusion is not so important, but maintaining good position of the fragments is essential. It must be remembered that a good cosmetic result can be obtained without perfect occlusion of the teeth, but good function requires perfect occlusion.

In all of these fractures the airway may be of concern and a tracheotomy may be necessary immediately, or may be necessary when fracture splints or arch bars are applied to the teeth and the nose packed to reduce a fracture.

Transverse and pyramidal fractures (see Fig. 5b) may be treated by cross wiring the lower fragment into the body of the opposite zygoma, especially if no teeth are present (see Fig. 5c). In pyramidal fractures, if most of the teeth are remaining and the nose fractured, I do a tracheotomy, then apply the fracture splints to the teeth and reduce the fracture and try to get good occlusion by cross wiring the lower fragment into the body of the zygoma, then finally and lastly reduce the nasal fracture. In most cases I have found that the lower fragment is stable, but the occlusion is not perfect and I resort to

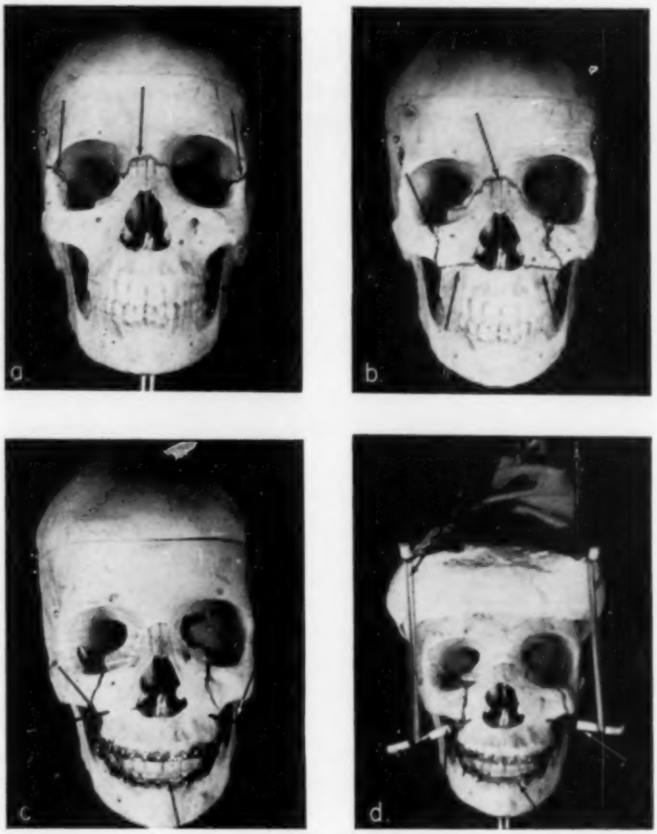

Fig. 5a. Fracture lines in cranio-facial fracture.

Fig. 5b. Fracture lines in transverse and pyramidal fractures from below upward.

Fig. 5c. Pyramidal fracture of maxillae using Kirschner wires for cross wiring and direct fixation into opposite zygoma. Fracture splints on teeth.

Fig. 5d. Pyramidal fracture with wires withdrawn from opposite zygoma into maxillary sinus so that traction can be applied to head cap. Fracture splints on teeth.

the head cap and traction with rubber bands after these wires have been withdrawn from the body of the zygoma (see Fig. 5d). The traction is usually forward and upward as is shown in Fig. 6a. Sometimes when the fragment is pushed upward traction must be applied downward and forward. Though flat plate X-rays show the fracture lines (see Fig. 6b) a stereo in the Waters position gives much more detail. The nasal

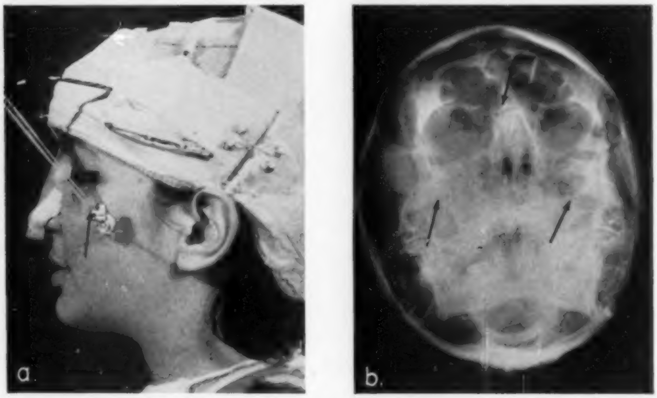

Fig. 6a. Pyramidal fracture with forward and upward pull of lower fragment.

Fig. 6b. X-ray view, Waters position, showing typical pyramidal fracture.

bones, when badly comminuted, should not be reduced until the maxillae are in good position, and then may be moulded into position a few days later if a good position is not secured at first. I have found it very difficult to use one pin across the lower fragment, as not infrequently it will be deflected into the fracture line of the opposite side and no traction can be obtained on that side.

Management of the cranio-facial or LeFort III type of fracture can be handled very much the same way as the transverse and pyramidal fracture, except that direct fixation cannot be done satisfactorily, due to the fact there is no adequately strong structure into which the wire may be secured. It is then

usually necessary, if open reduction is not done, to use the traction method, as well as fracture splints to the teeth.

The use of head caps is certainly not the most satisfactory method of applying traction, but I have found none better. Braiding the hair and then applying one of the "spray nets" to stiffen the hair helps some. In my experience the mobile type of fixation with traction is worth the effort, because all of these patients get a good occlusion.

CONCLUSIONS.

1. Use of the Kirschner wire for direct fixation of fractures of the middle third of the face has been found to be very satisfactory.

2. Less time is required to fix fractures by this method than by open reduction.

3. Use of the Kirschner wire to which traction can be applied is most satisfactory and there is minimum scarring at the entrance through the skin.

4. The use of two Kirschner wires crossing into the body of each zygoma has been found more satisfactory than trying to cross directly from one zygoma to the other in fixation of pyramidal fractures and gives the added factor that the point can be withdrawn into each maxillary and traction applied with a head cap, if the reduction has not been satisfactory.

5. Where fracture splints to the teeth must be applied and the nose packed for reduction of an accompanying fracture, tracheotomy is advisable, preferably through a transverse incision.

6. No accidents or infections have been encountered thus far in my cases.

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ELECTROMYOGRAPHIC STUDY ON RESPIRATORY MOVEMENTS OF THE INTRINSIC LARYNGEAL MUSCLES.*†

FUMIO NAKAMURA, M.D.,
YUTAKA UYEDA, M.D.,
YUTAKA SONODA, M.D.,

Kyoto, Japan.

It is well known that the larynx is employed in numerous ways, and that numerous factors are involved in its neurogenic controls. The behavior of the intrinsic laryngeal muscles under various functions must be dependent upon the central mechanism, of which, however, little is known. If the centers causing the laryngeal movements were different it is probable that a different pattern of activity would take place. This study was undertaken to differentiate the motor pattern displayed in the laryngeal muscles under various actions by recording the discharge of the individual motor unit.

In the present experiments only the respiratory activity is considered. The respiratory movements of the vocal cords in man were investigated by Pressman,[10] by recording a slow motion picture. He showed that basically the glottis widened during inspiration and narrowed during expiration. These movements are so slight in certain persons during quiet respiration as to be almost imperceptible, while, in dyspneic breathing, they increase in excursion so that the lateral movement of the cords during inspiration becomes progressively wider as inspiration becomes deeper and more forceful. By recording the smoked drum tracings, Negus[9] showed that the widening of the glottis preceded a contraction of the diaphragm, and narrowing occurred just before the beginning of

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†From the Department of Otolaryngology, Kyoto Prefectural Medical Colledge, Kyoto, Japan.

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expiration. Recently an investigation on impulse activity of the recurrent nerve and electromyographic recording of activity in the intrinsic laryngeal muscles was reported by Green and Neil,[8] showing that the abductor muscles fired during inspiration, while the adductors showed an activity during expiration, and that the inflation of the lungs abolished the activity in the abductor and excited the discharge in the adductors.

As these muscles were relatively inaccessible to the electromyographic examination in a human subject, it was decided to explore the movements which take place in anesthetized experimental animals.

METHOD.

Dogs were used throughout the experiments, anesthetized with intravenous sodium pentobarbitone, about 30 mg/kg body weight. The neck was opened at the mid-line, and the larynx was exposed, carefully avoiding injury to nerves and blood vessels. Access to the muscles was obtained by direct visual controls. Sometimes the trachea was cut at the lower margin of the larynx; in such cases the animals no longer breathed through the larynx. In order to produce dyspnea, animals were connected to a rebreathing bag, allowing them to rebreathe a limited volume of oxygen and to accumulate carbon dioxide.

Electromyographic recording was made by inserting a concentric needle electrode. The needle electrode led to a cathode ray oscillograph and loud speaker via a resistance capacity coupled amplifier. The action potentials were recorded by using a magnetic type oscillograph on a sheet of moving bromide paper on which the pneumograph was recorded simultaneously.

As the needle electrode of this type is not sufficiently selective to give information on the pattern of a single motor discharge, special care was taken to avoid an intermingling of the activities of other adjacent units, because, if more than three or four units were active it would be difficult to interpret the electrical records.

RESULTS.

The electrical activity in five intrinsic laryngeal muscles was examined. The thyro-arytenoid, crico-arytenoid lateralis and interarytenoid are the adductor muscles which cause approximation of the vocal cords with consequent narrowing of the glottis. The crico-thyroid is believed to regulate the length or tension in the cords, and to complete the degree of adduction. On the other hand, the crico-arytenoid posterior abducts the arytenoid cartilage and widens the glottis.

When the needle electrode was inserted into the muscle, it was found that the adductors, except the thyro-arytenoid, which remained quiet throughout the whole respiratory cycle, showed activity during expiration, while the abductor was active during inspiration. The features of motor neuron discharge which were recorded from the intrinsic laryngeal muscles during respiration, were similar to those described by Adrin and Bronk,[2] Bronk and Ferguson,[3] and Gesell, Magee and Bricker[6,7] for the phrenic and intercostal neurons; that is, during quiet breathing only a fraction of the motor units was active, and the activity in most of these consisted of a short train of impulses. The records exhibiting a characteristic pattern are illustrated herewith (see Fig. 1). Discharge frequencies of a single unit operating phasically were between five and 50 impulses/sec. In the adductors the frequency of impulses was the greatest at the start of expiration and gradually dropped away as expiration proceeded, and ceased at the end of expiration. On the other hand, in the abductor muscles the frequency was low at the start of inspiration and rose gradually as inspiration proceeded, *i.e.*, the intervals between successive impulses became progressively shorter. Its increasing rate of discharge reached a peak at the end of inspiration, where the firing abruptly ceased at or before expiration.

Although the majority of the motor units fired phasically, some units (see Fig. 2) showed a continuous train of impulses whose frequency rose and fell with the respiratory cycle, as if the steady continuous frequency was modulated by the rhythm of breathing. These units fired continuously

throughout inspiration and expiration: the abductor increasing in frequency during inspiration, while the adductors increased in rate during expiration. Many of the continuously discharging units fired at rather slow rate, namely, they increased their frequency from the range of 5-10 impulses/sec. during rest, to the range of 10-20 impulses/sec. during con-

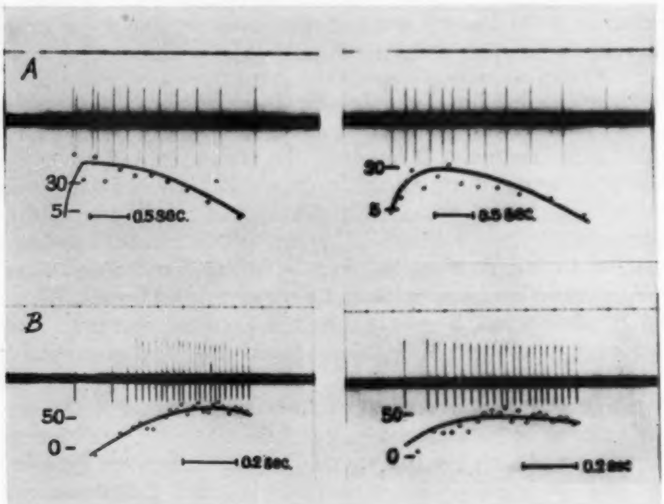

Fig. 1. Electromyogram recorded from crico-arytenoideus lateralis (A) and crico-arytenoideus posterior (B). The adductor shows decelerating activity, while the abductor exhibits a characteristic accelerating pattern. Lower line is graph of impulse frequency.

traction; however, sometimes a considerably high rate was observed, 50-60 impulses/sec. (see Fig. 2-B).

It may be assumed that functionally the motor units in laryngeal muscles fall into two groups. The members of the first group perform a phasic contraction during respiration and those of the second group serve to maintain the muscle tone underlying the phasic movements.

When respiration was stimulated by causing animals to rebreathe a limited volume of air the frequency of discharge

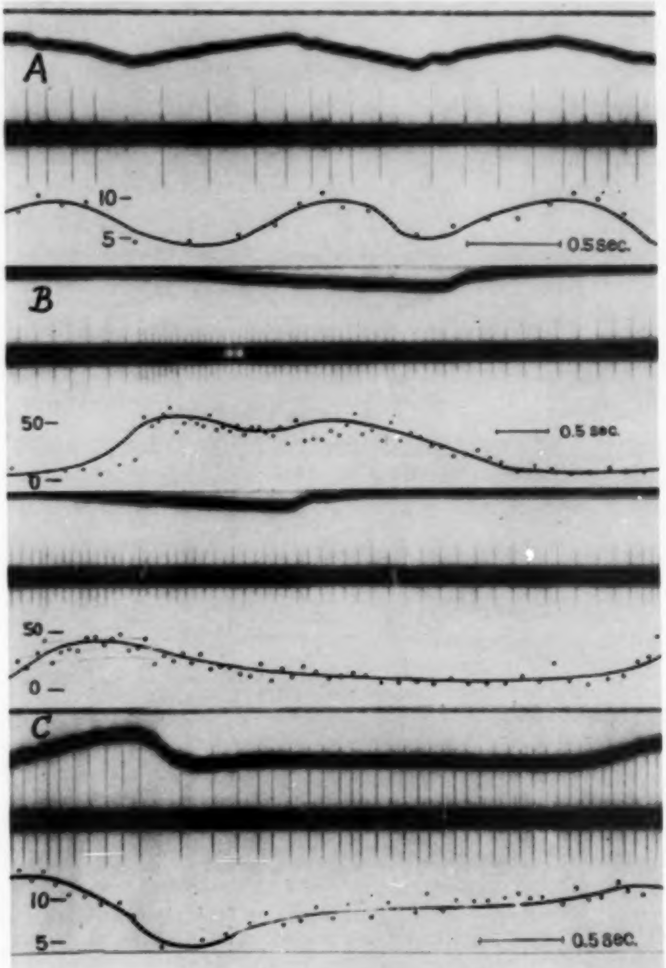

Fig. 2. Continuously discharging unit recorded from the adductors (A), (B) and abductor (C). These units fired continuously throughout inspiration and expiration, but in adductors, increasing in rate during expiration, and in abductor, increasing in rate during inspiration. Upper line is pneumogram, upwards movement indicating inspiration. Lower line is graph of impulse frequency.

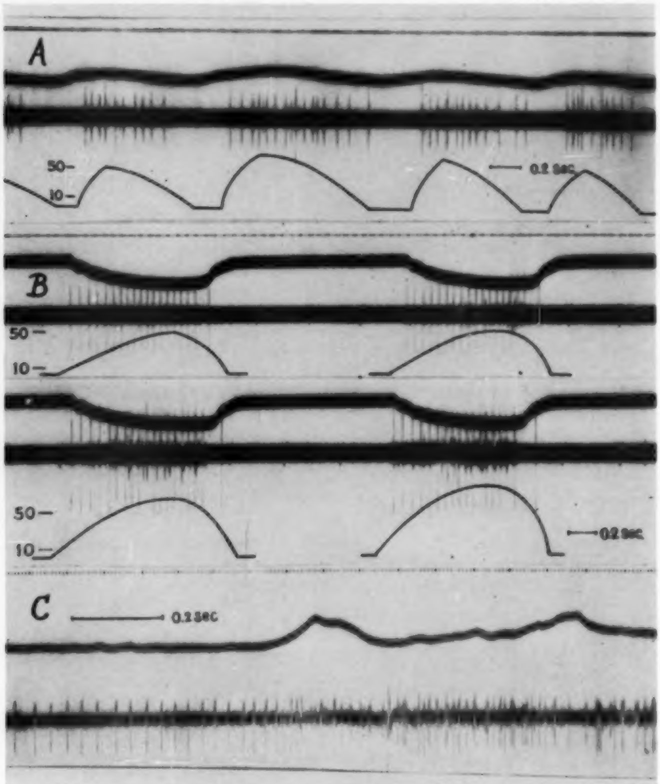

Fig. 3. Electromyogram recorded from crico-arytenoideus lateralis (A), crico-arytenoideus posterior (B), and continuously firing unit in crico-thyroideus (C) during dyspnea. The frequency of firing increased and other unit discharging impulses were recruited. Upper line is pneumogram (expiration down) and lower line is graph of impulse frequency.

and the train of impulses increased, and additional motor units which discharge impulses, were added or recruited (see Fig. 3). Continuously firing units also increased in their frequency as respiratory movements became more violent.

Effects of anesthesia are illustrated in Fig. 4. In such a case the frequency of impulses and the number of active

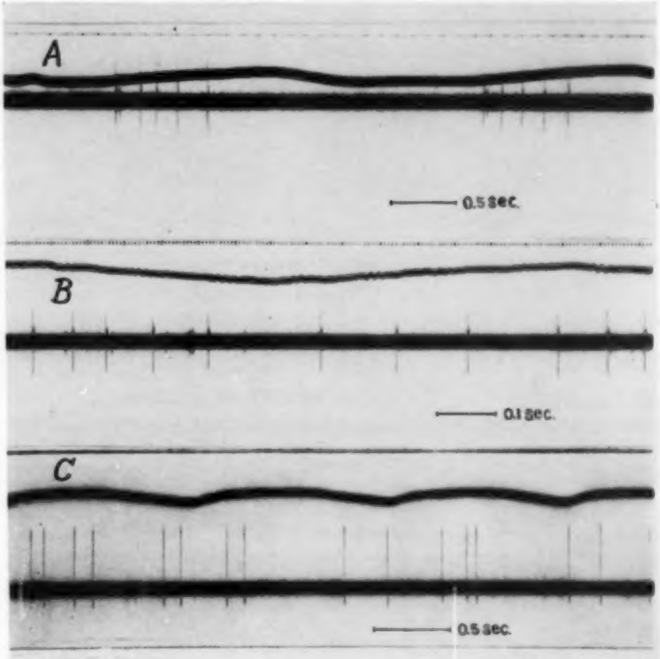

Fig. 4. Electromyogram recorded from crico-thyroideus (A), continuously discharging unit of crico-thyroideus (B), and of crico-arytenoideus posterior (C), showing the effects of anesthesia on respiratory activity. The impulse frequency decreased and intervals of each successive impulse become more or less at random. Upper line: pneumogram (expiration down).

fibers discharging impulses decreased so that the number firing in a train became fewer. The pattern of discharge lost its characteristic nature, and intervals of each impulse became more or less at random.

In order to eliminate the influence of air current on the muscle movements, the trachea was sectioned at the lower end of the larynx. No appreciable change in activity was observed, even when air was artificially blown into or sucked through the larynx asynchronously with the respiratory rhythm. When dyspnea was produced, an increase in activity

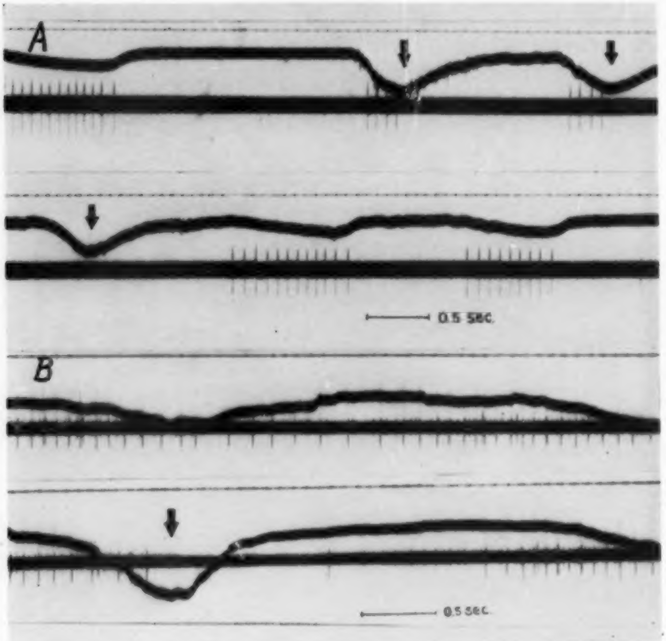

Fig. 5. Effect of inflation of lungs upon a phasically operating unit (A), and a continuously discharging unit (B). Arrows indicate inflation. Diminishing and abolishing of activity after inflation is obvious. Upper line is pneumogram.

invariably took place, regardless of an air flow through the larynx. It seemed that the laryngeal respiratory movements were not affected by local sensory information evoked by the force of air current.

The abolition of phasic activity in adductor muscles caused by inflation of lungs, reported by Green and Neil,[8] was also confirmed (see Fig. 5-A). Fig. 5-B shows the effect of inflation upon continuously discharging units. After strong inflation a continuous train of impulses during inspiration became abolished, but, during expiration they fired as usual.

DISCUSSION.

The firing pattern in the adductor muscles of the larynx would be regarded, according to Gesell and others, as a rapidly augmenting type characteristic of the intrinsic expiratory muscles, and that of the abductors as a slowly augmenting type characteristic of the genuine inspiratory muscles. In respiratory activity the laryngeal muscles' response is similar to that of the intrinsic respiratory muscles in anesthesia, dyspnea, and the reflex evoked by stretch receptors in the lungs. It might, therefore, he concluded that during respiration the motor neurones innervating the laryngeal muscles are influenced by the respiratory centers in a manner similar to those of the genuine respiratory muscles.

The intrinsic laryngeal muscles exhibit a basic tonic activity, as suggested by Jackson and Jackson.[12] The periodic widening and narrowing of the glottis is superimposed upon this underlying muscle tone. The tonic activity in respiratory muscles is said to have a significant role in maintenance of posture, particularly against the force of gravity; but, as in the larynx, the force of gravity acting on the cords might be so slight and negligible that it would not be unreasonable to suppose that movements of the cords would take place around the mid-position which might be determined by the balance between these tetanic contractions in a larger or smaller portion of motor units in the antagonistic muscles.

The problem, as discussed by Andrews[13] on the respiratory displacement of the larynx, "How is the balance maintained?" has not yet been explained satisfactorily. The continued activity of the laryngeal muscles during respiration after the detachment of the trachea and the great increase in activity when dyspnea was produced, indicate that the position or movements of the cords are not passively determined by the force of air current through the glottis chink.

It is said that the laryngeal muscles, as well as the muscles of the tongue, face and middle ear do not contain muscle spindles.[11] Fernand and Young[5] have classed the recurrent laryngeal nerve in rabbits as unimodal, containing few or no propioceptive fibers. Campbell and Murtagh,[4] reporting the

spectra in the human, goat, and cat laryngeal nerves, reached the same conclusion. It is logical to consider that the laryngeal muscles are controlled by α efferent alone. A tentative explanation would be that the position or movements of the vocal cords during respiration may be solely determined centrally without reference to local sensory feed-back. Lack in sense of position of the cords in human beings, and Negus' observation that the cycle of respiratory movements of the glottis slightly preceded the genuine respiratory cycle, giving an impression that constriction or dilation had already been prepared before the incidence of air flow, may support this point of view.

Regarding the useful results of respiratory movements of the glottis, there is no doubt that the effect of widening at the glottis chink at or just before inspiration is a reduction of resistance to an inflow of air. On the other hand, the effect of the constriction, beginning prior to expiration and continuing through it, is suggested by Pressman[10] to have a significance upon the phenomenon of air mixing within the lungs. It is widely known that respiration is shallow and somewhat irregular in case of a laryngectomized patient. This might probably be due to the lack of resistance or, in other words, appropriate "load" to an outflow of air. It might be safe to say that the laryngeal muscles, as well as the muscles of the wings of the nares and bronchi, should be called "the regulatory muscles of the respiratory passage," which serve to regulate the section of the respiratory passage, reducing the resistance to inspired air, and giving it the appropriate load to keep respiration deep and regular.

SUMMARY.

The electrical activity in five intrinsic laryngeal muscles of the dog during respiration was examined with electromyographic recordings. The abductor was active during inspiration, while the adductors showed activity during expiration, except the thyroarytenoideus, which remained quiet throughout the respiratory cycle.

The pattern of activity in the laryngeal muscles showed a close similarity to that of intrinsic respiratory muscles.

No change in activity after the detachment of the trachea indicates that respiratory movements of the glottis may be controlled centrally without reference to a local sensory information. Effects of respiratory movements upon respiration were discussed.

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NYSTAGMOGRAPH FOR CLINICAL USE.*

VICTOR GUILLEMIN, JR., Ph.D.,†
and
NICHOLAS TOROK, M.D.,‡
Chicago, Ill.

The photoelectric nystagmograph presented in this paper is similar in its principle of operation to the instrument described previously by Torok, Guillemin, and Barnothy.[1] The equipment described here is, however, much lighter and more compact, and incorporates several improvements that result in greater reliability and in simpler, quicker and more convenient recording of nystagmic eye motions.

The entire optical and photoelectric system of the new instrument is mounted upon a headband and goggle frame fitted to the patient. Recordings may be made with the patient in any position, seated, in bed or on a revolving chair. Preparation of the patient for a recording may be accomplished in a minute or two so that the whole process of making a record, either by thermic stimulation or by means of the rotating chair, requires little more time than the usual clinical procedure of visual observation of nystagmus.

The advantages of graphical recording are obvious. A graphical record shows many details that are not obtainable by direct observation, and an analysis of the graph provides data on the duration, frequency, change of frequency, amplitude and form of the nystagmus, that are valuable both in clinical practice and in vestibular research.[2,3]

Most of the recordings of nystagmus make use of the corneo-retinal potential difference picked up by electrodes placed at various positions in the immediate vicinity of the

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†Department of Physiology, University of Illinois, College of Medicine.

‡Department of Otolaryngology, University of Illinois, College of Medicine.

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eye. The usefulness of this method is clearly demonstrated in the recent work of Aschan et al.[4], who obtained very reliable and instructive nystagmographs in serial clinical investigations. We cannot agree, however, with the statement of these authors that the photoelectric method has been superseded by the method of potential pick-up. On the contrary, our experience in the laboratory and in the clinic shows that our photoelectric method gives excellent records and is most practicable in terms of convenience and economy of time required to obtain a record.

As previously described, the instrument makes use of the difference in reflection of infrared light from the dark iris

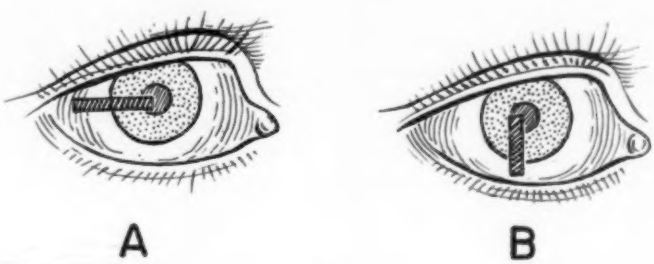

Fig. 1.

and the light sclera of the eye. A focused beam of infrared light forms an illuminated area on the eyeball approximately 1 mm. wide by 16 mm. long, so situated that it lies partly on the iris and partly on the sclera as shown in Fig. 1-A. This position is appropriate for the observation of horizontal nystagmus. To record vertical motions, the light beam is oriented as shown in Fig. 1-B. The light beam is fixed relative to the patient's head; therefore, any motion of the eyeball will vary the portion of the beam striking the sclera. Since the sclera has a higher reflectivity for infrared, as compared to the iris, the total amount of light reflected from the eyeball will change with every movement of the eye. This reflected light falls upon a photocell, located close to the eyeball, and

is converted to corresponding changes of electrical potential that are electronically amplified and recorded.

Fig. 2 shows a schematic diagram of the complete optical and electronic equipment arranged for recording nystagmus on the revolving chair. The same equipment is used when thermic stimulation is employed, except that the connections through rotating slip rings and stationary bruches are unnecessary.

Immediately in front of the eye, which is illuminated as described, are a pair of photocells. These are Bell laboratory

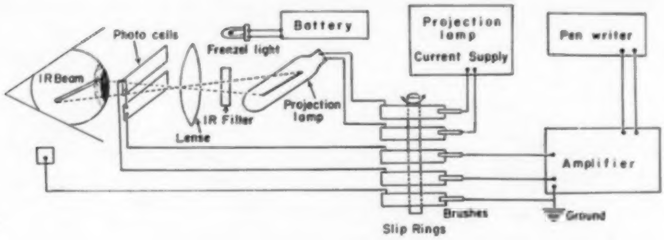

Fig. 2.

photovoltaic cells (sun batteries) in the form of small flat rectangular plates, 5 mm. by 20 mm. They are connected electrically in series so that their output is additive; that is, they function as a single cell.

The light source is a special projection lamp having a single straight filament that acts directly as a source of illumination. A short focus projection lense focuses an image of this filament upon the eyeball. A glass infrared filter is interposed in the light beam to absorb the visible light of the lamp. This prevents visual stimulation of the eye during the recording of nystagmus. The filter is mounted in a sliding holder so that it may be moved out of the path of the beam for visual focusing and positioning of the image on the eyeball.

A 20-diopter lense is mounted directly before the opposite

eye to be used for visual observation when desired, in the manner of the Frenzel glass. A small electric lamp, located behind this lense, gets its current supply from a portable dry cell battery. This lamp is well shielded and operates at low intensity, just sufficient to permit visual observation of the eye in a darkened room.

All the parts described thus far, with the exception of the dry cell battery, are mounted on a headband and goggle frame fitted to the patient's head.

Electrical connections from the photocells on the revolving chair to the stationary electronic amplifier are made via the usual slip rings, revolving with the chair, and stationary brushes bearing on these rings. Two similar connections are used for the electric current supply of the projection lamp. This is provided by a well-filtered low-voltage direct current source that is operated on the 115 volt, 60 cycle power lines. It is essential to operate the projection lamp on steady direct current, since the photoelectric system is fast enough to respond to the 120 cycle per second light intensity fluctuations of a lamp operating on alternating current. This direct current source is controlled by a switch having a "low" intensity position, used while focusing the beam on the eye, and a "high" position used when the infrared filter is moved into the light beam.

The amplifier is of the a.c. type with a flat frequency response over the range of one-half to 200 cycles per second. This range is adequate for recording practically all types of nystagmus, both spontaneous and induced, without appreciable distortion. The amplifier is provided with an electronic limiter that prevents excessive output signals due to blinking or large voluntary eye movements. The amplifier actuates a commercial pen recorder having a frequency response range of zero to approximately 100 cycles per second. The recorder thus limits the overall upper frequency response of the equipment.

The actual construction of the headband, goggle frame and optical equipment, is shown in Fig. 3, which shows both a front and back view. The housing for the projection lamp,

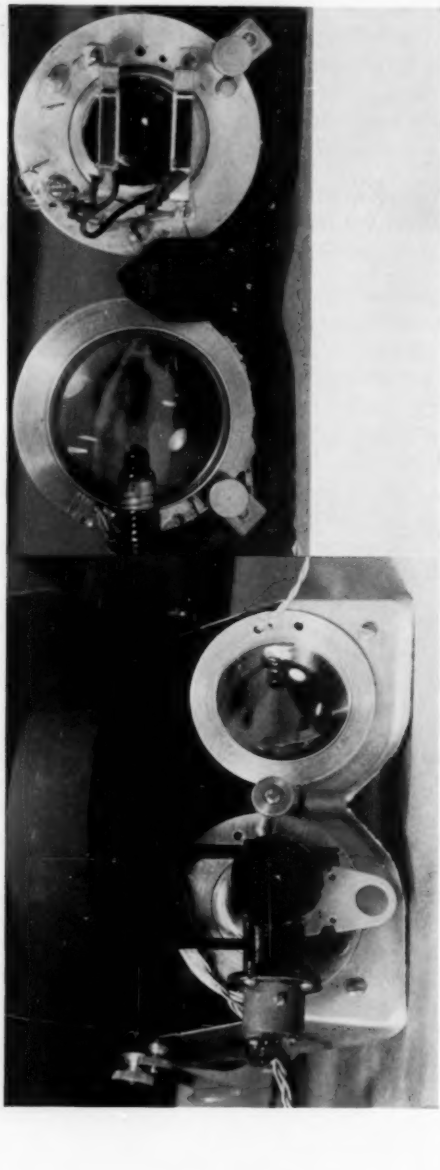

Fig. 3.

lense and infrared filter in its retractable slide is shown to the left of the front view. This whole assembly is mounted as a unit, in a sliding and rotating ball-and-socket joint that permits axial motion for focusing and also angular rotation. In addition, the optical assembly may be tilted in all directions for adjusting the beam to its proper position on the eyeball. All these adjustments are fixed by tightening a single thumb nut. Further adjustments are provided for headband size and nose configuration.

The Frenzel glass, together with its small illuminating lamp, is mounted on the opposite side of the goggle frame, and both the Frenzel glass and the optical assembly are mounted upon circular metal discs that fit into semicircular openings in the goggle frame. They are held in place by thumb screws and are easily removable from the goggle frame so that their positions may be interchanged, that is, the light beam may be positioned on the right eye with the Frenzel glass before the left eye, or vice versa.

The rear view of the goggle frame shows the projection lense with the two photocells before it, and the small lamp of the Frenzel glass. Fig. 4 shows the apparatus fitted to the patient's head.

The two photocells, as stated above, act as one. Actually, one cell would suffice; however, because of the great variation of head and nose sizes and shapes, the light beam may fall upon the eyeball in a slightly upward or downward slanting direction with various patients so that the reflected beam is directed respectively, somewhat downward or upward. In either case, one or the other of the two cells will be well illuminated by the reflected light. Thus, with two cells, the adjustment of the beam is less critical, and may be accomplished quicker and more easily.

The rotating chair (see Fig. 5), used with the above equipment, was assembled at low cost and is adequate for routine clinical tests. It has an electrical variable speed drive giving a range of angular velocities of the chair from 2.5 to 90 degrees per second (0.42 to 15 turns per minute) in either direction of rotation. There is no adjustment for angular

acceleration or deceleration. The chair reaches full angular velocity, upon starting, in about two seconds, and is stopped by a hand brake in less than one second.

Calibration of the equipment, in millimeters of pen excursion per degree of eye deflection, is accomplished by means of a simple perimeter (see Fig. 5), having two small neon

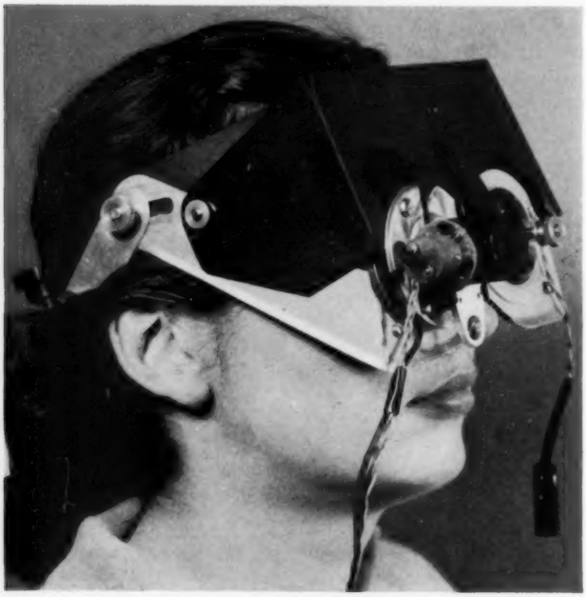

Fig. 4.

lamps that may be positioned at various angular separations as measured at the patient's eye, from 5 to 30 degrees of arc. A hand switch shifts the illumination quickly from one lamp to the other, and the patient is instructed to follow the light with his eyes while keeping his head at rest.

The whole equipment is inherently linear in response to well within its limit of precision, which is about 0.2 mm. for visual measurement of the pen record. This degree of line-

arity is found in the output of the photocell, in the response of the amplifier, and in the excursion of the pen recorder; however, when carrying out a calibration on a given patient there is a large factor of uncertainty, depending upon the precision with which he can follow the apparent motion of the light on the perimeter. A trained and cooperative sub-

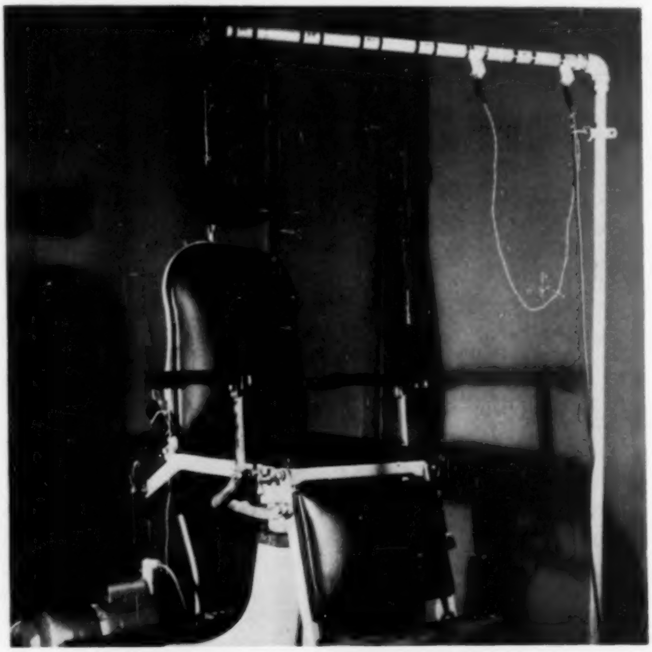

Fig. 5.

ject can repeat successive eye movement for the same perimeter setting within about 2 per cent, but an untrained or uncooperative patient may vary his eye motion as much as 10 or 20 per cent at the same setting. In such cases only a very rough calibration can be accomplished.

The overall sensitivity is ample for all recordings. A mo-

tion amplification of twenty to one is obtained readily; that is, a linear motion of 0.5 mm. at the surface of the eye may produce a pen excursion of 10 mm. Thus it is possible to record nystagmic motions so minute that they would not be noted by visual observation of the eye.

Photoelectric recordings of nystagmus has been described and used successfully by Pfaltz and Richter.[5] The principle

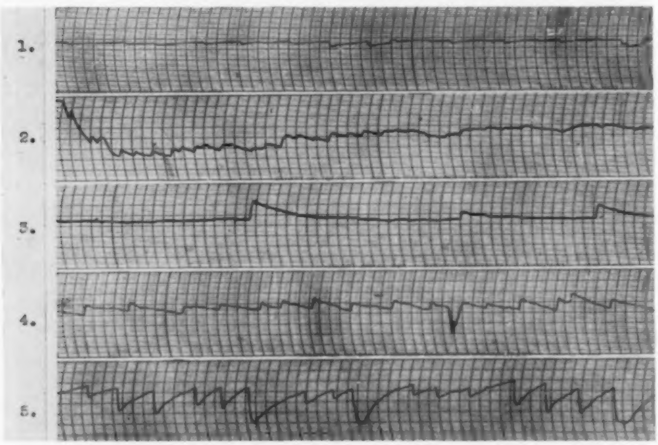

Fig. 6. Nystagmograms of Various Types. Five horizontal bars represent 1 sec. time. 1. Spontaneous nystagmus; small amplitude; constant frequency. 2. Postrotatory nystagmus, obtained through the electrically driven chair, 45°/sec. velocity and sudden stop; total duration within normal limits, nystagmus frequency elevated. 3. Postrotatory nystagmus, obtained under identical conditions as graph No. 2; total duration normal; very low frequency but larger amplitude. 4. Thermic nystagmus, obtained by 10 cc. 68° of water; even amplitude, normal frequency; the one irregular excursion downward is the result of a blinking of the eyelids. 5. Thermic nystagmus, 10 cc. 68° water; larger and uneven amplitudes; frequency within average normal limit.

of operation of their apparatus is, however, somewhat different. They illuminate the entire area of the iris plus the near adjacent areas of the sclera on both sides of the iris. Two photocells, positioned laterally and connected in opposition, so that their output potentials are opposed, record the simultaneous and opposite changes of illumination on both sides of the iris when the eye moves.

With the use of a focused light beam as described here, only one iris-sclera boundary is illuminated. It is thus possible to make recordings of first degree nystagmus where the eye is deflected so far to the side that one edge of the iris is occluded by the eyelids. When both second and first degree nystagmus is to be recorded in succession, the beam may be so positioned that one or the other edge of the iris lies well within the beam both in the forward and the sideways deflected position of the eye.

The photoelectric study of nystagmus requires that the eye be held open during the actual time of recording. This does not appear to have any effect upon the nystagmic response when the patient is in a darkened or dimly lighted room. The opened eye is, of course, required in any case where the recording is to be checked by simultaneous observation through the Frenzel glass. Actually this means of observation was provided in the present apparatus primarily to check its operation during the development and testing period. The recorder has proven so reliable that visual observation is seldom used in routine clinical tests.

Fig. 6 shows several typical records obtained with the photoelectric nystagmograph.

SUMMARY.

This paper describes a photoelectric nystagmograph, using invisible infrared light, suitable for recording all types of nystagmic eye motions, except pure rotatory nystagmus. It is particularly well adapted for routine clinical tests with thermic or rotatory stimulation, but is also suitable for physiological research. It provides very reliable records that show all the details of form, amplitude, frequency and duration of the vestibular reaction.

The apparatus comprises a headband and goggle frame, fitted to the patient's head, upon which the optical and photoelectric equipment is mounted. This is connected to an electronic amplifier and pen recorder that supplies an immediate pen record of the nystagmus.

The recording is conducted in a dimly lighted room. The

motions of one eye supply the infrared light signals for the recorder. The other may be observed simultaneously, if desired, through a 20-diopter lense in the Frenzel method.

By a simple operation the optical assembly and the Frenzel glass may be interchanged so that either eye may be used to supply the record.

In clinical use, recordings may be made in only a few more minutes of time, and with no more discomfort to the patient than in the usual procedure of visual observation of nystagmus.

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SHAMBAUGH PRIZE—COLLEGIUM O.R.L.A.S.

Dr. Glen E. Wever, of Princeton, was recently awarded the Shambaugh prize which is presented every second year by the Collegium Otorhinolaryngologicum Amicitae Sacrum, for outstanding work on the physiology of the auditory organ.

EUSTACHIAN TUBE BIOPSY CANNULA.

MAHMOUD K. MUFTIC, M.D.,*

Basrah, Iraq.

Tubal obstruction usually affects the nasopharynx in various ways ranging from acute and chronic inflammation of the adenoids to benign neoplasm and hypertrophy of the nasopharyngeal tissues.

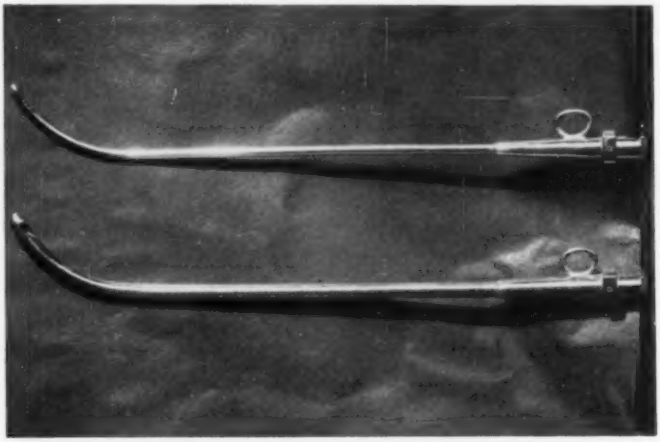

Fig. 1. Muftic's Biopsy Cannula for Eustachian Tube.

The usual procedures for investigating the cause of tubal closure, posterior rhinoscopy, nasopharyngoscopy, tubal insufflation, etc., were not productive of proper analysis in the case in question; consequently it was necessary to establish a simple routine procedure which would permit biopsy from the tubal orifice and from Rosenmuller's fossae, thus giving a histopathological diagnosis of the obstruction.

*King Fassail Royal Hospital, Basrah.

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To simplify the technique, an instrument† for obtaining specimens for biopsy was designed in the shape of a Eustachian tube catheter adaptable to a B-D syringe (LL). The end piece may be of two different types resembling the endometrial cannula-curette according to Raydal and Novak, but of a smaller size.

This cannula-curette is introduced by the same technique as in ordinary catheterization of the Eustachian tube. The catheter is introduced (with or without local anesthesia), and when it is engaged in the tubal orifice or well in Rosenmuller's fossa, strong suction is applied by aspirating the syringe or adapting cannula to a suction unit. After complete suction, the cannula is withdrawn and the tissue is removed from the cannula by strong insufflation, and placed in the proper fixing solution.

The stain for the small biopsy is made according to Papanicolaou, and thicker pieces are embedded for histopathological investigation by the usual staining techniques.

†These instruments are made from my design by Down Bros. and Mayer and Phelps. 92 Borough High Street, London S.E. 1, to whom I am most grateful.

AMERICAN SOCIETY OF FACIAL PLASTIC SURGERY.

The Annual Spring Meeting of the American Society of Facial Plastic Surgery will be held March 10-11, 1958, at Columbus, Ohio. For further details write Dr. Samuel M. Bloom, Secretary, 123 East 83rd Street, New York (28), N. Y.

ANESTHESIA METHODS FOR BRONCHOSCOPY AND THEIR USEFULNESS IN PRACTICE.*

E. J. KNUDSEN, M.D.,
H. RASMUSSEN, M.D.,
H. RUBEN, M.D.,
and
P. TRAUN-PEDERSEN, M.D.,
Copenhagen, Denmark.

Bronchoscopy, when introduced into clinical practice about the turn of the Century, was employed chiefly for removal of foreign bodies. In the course of years, the use of diagnostic bronchoscopy has steadily increased.

Bronchoscopy, carried out in deficient anesthesia, is an extremely disagreeable experience to the patient; moreover, the diagnostic value of bronchoscopy in a patient offering resistance is doubtful; and finally, bronchoscopy under such circumstances involves a risk of injury.

Endeavors have, therefore, been made to find a satisfactory method of anesthesia, but the multiplicity of proposals proves the difficulty of the task. The main troubles are that the anesthetist and the surgeon work in the same field and, therefore, easily get in each other's way, and that the field concerned is sensitive with very brisk reflexes.

Formerly, the choice lay between local and general anesthesia, the latter in the form of inhalation anesthesia. Within recent years a number of methods, new in principle, have been introduced. We have found it appropriate to try some of these in practice and attempt to assess their usefulness.

The demands to be made on an ideal method are the following:

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*From the Finsen Institute, Copenhagen; Anesthesiology Department (Head: H. Ruben, M.D.); and E.N.T. Department (Head: H. Rasmussen, M.D.).

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1. A minimum of risk to the patient.

2. Removal of discomfort to the patient.

3. Undisturbed working conditions for the surgeon.

4. Simplicity of technique and apparatus.

5. A short restoration period (of particular importance in cases of out-patients).

Local anesthesia, with or without premedication, was previously the most frequently employed method for adults, and is still used in some cases. With reference to the above-mentioned demands, it is seen that:

1. The method, on the assumption of adequate dosage, fulfills the requirement of safety.

2. In few cases only does it remove the discomfort to the patient.

3. It rarely renders possible undisturbed examination. In cases of nervous patients it is impossible to carry through bronchoscopy in local anesthesia alone.

4. The technique is simple.

5. It is suitable for out-patients.

In cases unfit for local anesthesia inhalation anesthesia was previously the only other possibility. Examination then had to be performed during the restoration period, after the dosage had been stopped. The examination requires deep anesthesia. The degree of the consequent depressed respiration and a possible cyanosis are difficult to follow during endoscopy in a dark room. The anesthetist will often have to intervene while the surgeon is at work, either to ventilate with oxygen or to add a supplementary amount of ether, for instance. In case of difficulty with the introduction of the bronchoscope, a laryngeal spasm may occur, which will often start a series of unpleasant complications. Regarding the above-mentioned demands we have found that:

1. The method is not without risk.

2. The discomfort of bronchoscopy is replaced by discomfort of anesthesia.

3. The surgeon cannot work undisturbed.

4. The technique certainly is simple, but it is difficult to manage in practice.

5. The restoration period is fairly long, and the method, therefore, is unfit for out-patients.

The only cases where inhalation anesthesia may be indicated are those of bronchoscopy in children, where the modern forms of general anesthesia may be difficult to administer. In cases of children with obstructing or potentially obstructing foreign bodies in the air passages any kind of general anesthesia must be regarded as contra-indicated. Non-obstructive foreign bodies in the air passages of children can often be removed in vinyl ether-and-ether anesthesia; but an excellent method has been indicated by Toker, using thiopental-sodium and succinyl-choline-iodide, and cuirass respirator *(vide infra).*

MODERN ANESTHETIC METHODS.

A. Local anesthesia suplemented by general analgesia, obtained with pethidine intravenously.

B. General anesthesia obtained with barbiturates supplemented by short-acting relaxants.

A. Local Anesthesia Supplemented by Pethidine Medication.

A previous investigation showed that endoscopy through the pharynx, including bronchoscopy, could be greatly facilitated by injecting pethidine intravenously, due partly to the depressing effect of pethidine on the laryngeal and pharyngeal reflexes, and partly to the mentally relaxing and pain-stilling action of pethidine in the doses used, an action which may be characterized as one of general analgesia. Not infrequently there is found amnesia with regard to discomfort of the examination.

The method has now been employed for bronchoscopy in more than 400 cases at the Finsen Institute during the past

six years, with an exceedingly favorable result. With reference to the previously mentioned demands we have found that:

1. The risk involved must be supposedly less than that of local anesthesia alone, as the amount of anesthetic, if pethidine is used, can be reduced. Oximetry shows that the reduction of the oxygen saturation in cases with pethidine medication is slight, being of the same order as at bronchoscopy in local anesthesia alone, where a reduction occurs when the bronchoscope causes obstruction, *e.g.*, when it is introduced into one of the bronchi. This can possibly be explained by the way in which the depressing effect of pethidine on the respiration is abolished by the stimulating effect of the intervention itself.

2. Pethidine greatly reduces the discomfort to the patient. Reactions in the form of nausea are rare; the skin occasionally becomes pale and slightly moist, but the blood pressure does not fall, and there is seen only the minor rise in pulse rate which corresponds to the parasympathicolytic action of pethidine. Liberation of histamine with transitory redness along the course of the vein has been seen in a few instances, but no bronchospasms or collapse.

3. By employing local anesthesia it has, in the great majority of cases, been possible to carry through undisturbed and thorough bronchoscopy, most often including the taking of biopsy specimens and use of the telescope.

4. The method is simple and, if necessary, can be practiced by the surgeon alone, aided only by a nurse to watch the patient during and after the operation.

5. The method is suitable for out-patients, the majority of whom can resume their daily work after a few hours' rest. After removal of the bronchoscope the cough reflexes will suffice to bring up any blood or mucus.

Technique.

We used between 50 and 200 mg. (on an average about 100 mg.) pethidine in a 1 per cent solution. A good technique of local anesthesia is required to obtain a favorable result.

After careful spraying of the mouth and throat, 8 to 10 ml. of one-half per cent pontocaine with adrenaline 1:200,000 can, with advantage, be injected in between the vocal cords by means of a syringe fitted with a blunt, curved cannula, which can be passed down behind the epiglottis of the sitting patient. The cough produced by the application will spread the injected pontocaine in the trachea and bronchi.

Intravenous injection of pethidine is thereafter started; up to 50 mg. is given within about 30 seconds, and afterwards supplemented according to requirement. Maximum response to intravenously injected pethidine is obtained after a few minutes.

B. General Anesthesia.

The use of barbiturates combined with relaxants was first described about four years ago, and various modifications of the technique have already been suggested. These represent different solutions of the essential problem of oxygenation during the induced apnea.

Evaluation of the barbiturate-relaxant method with regard to fulfillment of the stated demands has shown that:

1. The method involves a much greater risk to the patient than local anesthesia plus pethidine method, because it requires a faultless functioning of a rather complicated technical apparatus, as well as an ideal, preferably firmly established cooperation of surgeon and anesthetist.

Failure of a link in the procedure, *e.g.*, a block in the intravenous cannula, leakage or stoppage of the oxygen supply, trouble with the introduction of the bronchoscope, etc., may within a very short time cause complications, which in the dark room may be difficult to recognize and treat sufficiently early. Experience will reduce the incidence of such complications, but the risk is always present. We have seen no severe complications in our series, but a few times interruption was necessary due to technical difficulties involving a risk of hypoxia.

2. The discomfort to the patient before and during the operation has been eliminated. The discomfort following the

intervention is probably somewhat greater than after local anesthesia supplemented by pethidine intravenously.

3. The method yields very good conditions of operation, varying with the different modifications, *(vide infra).*

4. The method requires the assistance of a specialist in anesthesia.

5. The restoration period is sufficiently short to render the method serviceable for out-patients.

The various principles of oxygen supply and the techniques employed will be briefly reviewed.

I. Intermittent ventilation has been suggested by Churchill-Davison, among others. Premedication with morphine and atropine is given. After intravenous injection of 300 to 500 mg. thiopental sodium and 60 to 75 mg. succinylcholine iodide, hyperventilation is carried out for 30 to 60 seconds, with pure oxygen by means of mask and bag. The vocal cords are thereafter sprayed with a local anesthetic. (This has been done in all modifications of thiopental and succinylcholine anesthesia for bronchoscopy, because the relaxant effect vanishes prior to the effect of the barbiturate, so that without local anesthesia removal of the bronchoscope will often be followed by violent coughing and laryngeal spasm). The bronchoscope is then introduced, while at the same time the patient is ventilated with oxygen as often as possible, through a cut rubber tracheal catheter, passed so far into the Negus bronchoscope that it fits airtight.

Oximetry shows that adequate oxygenation can be maintained in this way. Such frequent ventilations in the bronchoscope are very inconvenient to the surgeon, but they can, to a great extent, be done during intervals of examinations, while the surgeon is changing optical instruments, or the like.

The method takes a certain account of the Co_2 elimination, being, therefore, fit to be used over a fairly long period, providing curacite is constantly added for the purpose of maintaining apnea. Supplementary doses of a barbiturate are rarely necessary, when the examination does not extend beyond 15 to 20 minutes.

II. The oxygen diffusion method has been proposed by Barth for bronchoscopy. This method starts with ventilation, using oxygen for three to five minutes, without reinhalation of previously exhaled air (one-way-valve), whereby the nitrogen of the pulmonary air is replaced by oxygen. Thereafter the barbiturate and relaxant are given, until complete apnea has occurred, which is maintained throughout the intervention. During the bronchoscopy pure oxygen is conducted through a lateral tube in the bronchoscope with side holes.

We found that, using this method, a constant maintenance of apnea is necessary, because otherwise the oxygen in the lungs will be "diluted" again with nitrogen, and the oxygen diffusion to the blood thus be reduced.

Oximetry showed satisfactory values, providing the above requirements are met. As, however, no Co_2 is eliminated by this procedure, apnea lasting more than 15 minutes involves a risk of Co_2 intoxication, cf. Barth's own statement after pCo_2 measurements.

III. The insufflation method has been mentioned by Cheatle and Chambers, and others. After administration of barbiturate and relaxant, the patient's lungs are ventilated two or three times with pure oxygen. The bronchoscope is then introduced, and about one liter of oxygen per minute is conducted through a thin catheter passed down to the carina.

The method was found suitable for very short examinations only (Cheatle and Chambers themselves stated five, or ten minutes at most), because the oxygenation is not reliably effective, and Co_2 is accumulated.

IV. The cuirass respirator method has been indicated by Toker, and Green and Coleman. After administration of a barbiturate, a previously fitted respirator cuirass is placed on the patient's thorax and abdomen, and one makes sure that the respirator functions to satisfaction. Then a relaxant is given, and it is controlled so that the respirator takes over the patient's respiration in a satisfactory way. If so, the anesthesia can be continued as long as is desirable, affording ideal and undisturbed working conditions for the surgeon.

In stocky, fat patients, as well as in patients with a stiff emphysematous thorax, it has been found difficult and in some cases impossible, to obtain sufficient change of air by this method.

The apparatus being large and expensive, the method is usually employed in special wards.

V. The ventilation bronchoscope has been constructed by Mündnich and Hoflehner, and its use has been described by Kjaer, among others. It is a Negus bronchoscope, provided with side holes at the distal end, so that both lungs are ventilated, even with the bronchoscope passed down into one bronchus. The upper end can be closed by a glass pane. Through a side inlet close to the upper end of the bronchoscope the patient can be ventilated with gases from an ordinary anesthesia machine.

The patient's lungs can thus be ventilated through the bronchoscope during the whole period of bronchoscopy. If airtight closing round the bronchoscope is desired, this can be obtained by manual pressing of the soft tissue above the larynx against the bronchoscope. During prolonged bronchoscopy it is an advantage to be able to ventilate with a nitrogen oxide mixture, for instance, which allows reduction of the theopental sodium amount used and insures the patient's remaining asleep.

When a telescope is used, the glass pane can be replaced by a rubber diaphragm, through which the telescope can be passed airtight. Biopsy specimens cannot be taken simultaneously with the ventilation, but can be taken during a pause in this, especially if the patient has been hyperventilated in advance.

The method is suitable for bronchoscopies where prolonged and undisturbed examination is desired, *e.g.*, in the teaching of diagnostic bronchoscopy; but it is unsuitable for bronchoscopies for the purpose of taking biopsy specimens.

CONCLUSION.

The practical result of our investigations, in connection with testing of the various methods, is that we still prefer

local anesthesia supplemented by pethidine medication as standard method, especially in cases of old and very sick patients, where this method is supposed to involve the least risk. A few patients with very brisk reflexes, or very nervous patients, in whom it has been found impossible to introduce the bronchoscope after local anesthesia plus pethidene, we prefer to anesthetize with barbiturate and relaxant, and use ventilation bronchoscope or, when biopsy has to be made, the cuirass respirator method. In cases where anatomical conditions render examination in local anesthesia plus pethidine difficult, *e.g.*, a short stiff neck, long teeth, or the like, one must, however, be prepared for difficulties, also when employing the method with barbiturate and relaxant.

SUMMARY.

Early and modern methods of anesthesia for bronchoscopy have been reviewed, with reference to our experience in their use.

Local anesthesia supplemented by pethidine intravenously has been found satisfactory, the method being fairly safe, easy to carry out, and yielding sufficiently good operative conditions in the great majority of patients.

General anesthesia, using barbiturates and short-acting relaxants, yield ideal conditions of operation, but has been found to involve a greater risk to the patient.

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DYSPLASTIC DYSPHONIA:

Minor Anomalies of the Vocal Cords Causing Persistent Hoarseness.*†

GODFREY E. ARNOLD, M.D.,

New York, N. Y.

THE SIGNIFICANCE OF THE VOICE FOR COMMUNICATION.

Speech is the fundamental prerequisite for the intellectual development and the social integration of man. Due to its complex nature and to the manifold relations between speech and all phases of human activity the study of speech is shared by a large number of various sciences. Ranging from acoustics to zoology, almost every science shows a well-defined interest in some problems of speech and advances the composite knowledge by specialized contributions.

This variety of scholastic viewpoints produced many definitions of the terms dealing with speech. Since scientific terminology is fully covered by the disciplines of linguistics, or speech psychology, there is no need to discuss it here; however, the common usage of these terms deviates from academic parlance. Let us first clarify some of these discrepancies, particularly with regard to the concepts of language, speech, and voice.

Language is defined in Webster's dictionary as the generic term, denoting in its most extended use any mode of conveying ideas. Tongue is the Anglo-Saxon term for language, especially for spoken language. Speech refers to oral communication and represents the faculty of expressing thoughts by audible words or articulate sounds.

Articulation is the utterance of the elementary sounds of a language by the appropriate movements of the speech

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†From the Diagnostic Services (G. E. Arnold, M. D., Clinical Director) of the National Hospital for Speech Disorders (Lynwood Heaver, M. D., Director).

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organs, particularly of the tongue. *Voice* is produced by vibration of the vocal cords in the larynx. In addition to these scientifically correct definitions, indicated as such by different typesetting, Webster explains other usages, including their interchangeable meaning as synonyms.

The *voice* is one of the audible functions of the larynx, in particular of the vocal cords. It is this act of phonation which makes human speech suitable for audible communication. Expressed in the terms of the acoustic engineer, the voice represents the carrier wave. In further analogy to the superimposition of the vibrations of speech or music by amplitude or frequency modulation of the radio carrier wave, the acoustic characteristics of the speech sounds or vocal timbers are added to the laryngeal voice by the articulatory movements of the speech organs.

Following this technical example, we may compare the disorders of human communication to a disturbance in a radio station. If the material to be broadcast is lacking, or if the performers fail for any reason, the diffusion of ideas by language or music will be deficient. On the other hand, a failure in the acoustic system of microphones, cables, and amplifiers interferes with the proper modulation of the carrier wave, causing distortion or unintelligibility of singing and speech. Finally, when the emitters of the carrier wave break down, no radio signal will be on the air to carry the audio frequencies produced by the performing speakers or singers. It is this function of the human voice as a carrier wave for the modulation of speech sounds by articulation, and thus for the audible expression of thoughts, which will be considered in this paper.

LARYNGEAL PATHOLOGY AND PHONATION.

The voice can be impaired by many abnormal conditions of the larynx. These may be *acute*, like infections, or *chronic*, like permanent changes in structure; further, they may be of *peripheral* origin, such as in laryngeal injury, or of *central* origin, as a result of some brain pathology. Previously, one used to differentiate also between *organic* lesions, which would be recognizable by some changes in structure or

motility, and *functional* disorders, which would leave the structure intact while deranging the audible function.

Similarly to other medical specialties one has lately recognized that no such artificial division can be made. Sometimes marked structural abnormalities may be associated with excellent vocal function. In other cases severe functional losses are present in a larynx which appears normal to the eye. Between these two extremes are found the large majority of cases showing a combination of these two observations; moreover, the advances of bio-chemical and physiologic research demonstrate well-defined abnormalities in such diseases which were hitherto regarded as functional. Schizophrenia is an example. Hence, one prefers to classify diseases according to their etiologic causes, at least as far as presently distinguishable. With regard to vocal pathology, increasing usage is made of an etiologic terminology, which has replaced the older symptomatologic classifications.

DYSPLASTIC DYSPHONIA.

In a large center for voice and speech disorders the exceptional cases are more frequently seen than in a regular clinic for ear, nose, and throat diseases. For this reason, we encounter a relatively large number of patients whose hoarseness has been noticed since early childhood. Others noticed the onset of their chronic vocal disability at the time of puberty. Occasionally, such patients also report that some of their near relatives seem to have a similar disability. It would, therefore, appear that there exist *hereditary, congenital*, and *post-mutational* types of chronic hoarseness.

Laryngoscopic examination of these patients frequently reveals minor anomalies of the larynx. While the well-known signs of the common laryngeal diseases are absent, one finds a great variety of structural abnormalities. These affect the dimensions, proportions, relative positions and the bilateral symmetry of all laryngeal parts. In previous years such findings were often reported in great detail. Obviously, the authors hoped to correlate their visible findings with the audible disorders of the voice. While those observations

remained isolated contributions to the then obscure correlation of structural peculiarities with losses of function, no general conclusions could be drawn. After sufficient evidence had been accumulated it is now possible to arrive at a precise diagnosis in most of these cases.

As usual, the case history assists in the differentiation of congenital and acquired conditions, and in addition, may present indications of hereditary or post-mutational types. Routine otolaryngologic examination establishes the absence of infections or traumatic ailments. If necessary, the customary laboratory and X-ray studies help to rule out general diseases. More important is the corroboration of retarded physical maturation, hormonal imbalance, or constitutional debility by similar findings in other parts of the body. When, finally, the finding of a congenital laryngeal abnormality can be correlated with the presenting vocal disorder, the diagnosis of dysplastic dysphonia, due to developmental hypoplasia of certain parts of the larynx, can be established with certainty.

The psychological report is less helpful in such cases, for it is difficult to distinguish which part of the psychologic deviations, if present, are due to the secondary reaction of the individual to his disability, and which part may have been of primary contributing significance. Sometimes, however, the psychologist reports infantilistic signs which then agree well with the concept of a psycho-somatic retardation of the emotional and physical development.

MINOR LARYNGEAL MALFORMATIONS.

Since the larynx is a single organ whose two halves pertain to the two sides of the body, it is easy to understand that the slightest irregularity in the development of either side will remain permanently visible in the form of asymmetrical configuration. In fact, laryngeal asymmetry had been frequently described by the older authors. An abundant variety of such observations had been analyzed in the encyclopedic review by Beck and Schneider (1926). They demonstrated that any part of the larynx may be the seat of congenital

malformations. Vocal disturbances are to be expected particularly when the vocal cords are affected. Other regions may also disturb the voice or add pathologic noises to expiration. One example is the pseudo-syrinx described by Jackson and Jackson. This is a subglottic stenosis of the trachea which causes dyspnea and a crowing sound on coughing.

As is well-known, the vocal cords perform the vibrations which produce the primary laryngeal voice. Any irregularity in the length, breadth, thickness, specific weight, muscular development, position, insertion, motility and contractility, in short any asymmetry in the physical properties of the vocal cords must affect the acoustic qualities of the voice.

Reker published, in 1938, a detailed phoniatric study of the correlation between minor laryngeal abnormalities and persistent vocal disabilities. He came to the conclusion that some of these conditions are hereditary; others are simply present since birth and are called congenital; a third group appears after puberty, apparently being due to a maldevelopment of the infantile into the adult larynx, which would represent a developmental type of dysphonia. Since four of his 18 cases showed additional asymmetry of the face, and since five cases revealed palatal asymmetry, he assumed the presence of a generalized constitutional debility of the peripheral organs of speech, at least in those cases. Fig. 1 shows a case of congenital palatal malformation.

This combination of internal asymmetries of the larynx with other visible anomalies was also found by Tarneaud. In his monograph on the laryngopathias (1944) he mentioned the combination of laryngeal displacement with spinal skoliosis. In some cases the asymmetry of the thyroid cartilage may be felt by the palpating finger. Luchsinger mentioned in his textbook (p. 98) that these palpable asymmetries are a frequent finding in cases of constitutional weakness of the voice.

Similar observations were made by Garde, whose recent case showed unilateral hyperplasia of many skeletal parts on the right side, associated with laryngeal asymmetry and dysplastic dysphonia. Luchsinger reported three cases of

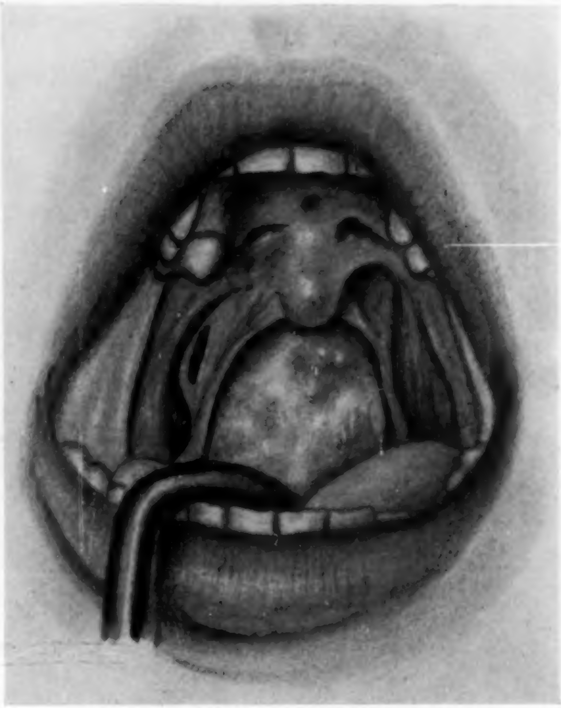

Fig. 1. Congenital Malformation and Asymmetry of the Palate.

congenital hypoplasia of the right vocal cord, one associated with hypoplasia of the right side of the tongue. All three patients suffered from congenital dysplastic dysphonia. This combination of laryngeal and lingual asymmetry had also been investigated by Motta. In a monograph on the accessory chambers of the larynx, Bartels compared the human anomalies with the anatomical findings in primates and other mammals.

Arnold (1947) gave a detailed analysis of a severe laryn-

geal malformation with congenital dysphonia. History, laryngoscopy, X-rays, anthropological report, and the vocal status led to the diagnosis of a laryngeal fracture during the complicated birth (see Fig. 2). Similar to the classifications of other congenital malformations this case demonstrated the necessity of distinguishing between *constitutional* maldevelopments and acquired *connatal* malformations. Hence, there exist cases of connatal traumatic dysphonia. His nine other observations of laryngeal asymmetry were published

Fig. 2. Connatal Malformation of the Larynx due to Laryngeal Fracture by birth injury.

in 1948. Table I shows the various forms of asymmetry, and their association with several types of dysphonia, the majority being of congenital origin.

VOCAL CORD SULCUS AND DOUBLE VOCAL CORDS.

The vocal cord sulcus is a fine longitudinal furrow on the medial edge of the vocal cord. It may extend over the entire length of the cord, or may be limited to a segment of variable length; its depth is also variable, ranging from a faint line to a deep partition of the cord. In the latter case it divides the cord into two portions, an upper or lateral lip, and a lower or medial lip. This is then called a double vocal cord. There may even be an accessory ventricle behind a very deep sulcus. The sulcus may be unilateral, bilateral, or may be

more noticeable on one side. Frequently it is associated with other laryngeal or oral asymmetries (see Fig. 3).

This condition is rare as far as the general population is concerned. In a specialized voice clinic, however, the sulcus of the vocal cord can be seen quite frequently. At the National Hospital we observe a few cases among about 3,000 patients each year. Arnold counted 12 cases among 1250 adults

TABLE I.

NINE CASES OF LARYNGEAL ASYMMETRY FOUND AMONG 1250 SOLDIERS SUFFERING FROM DISORDERS OF VOICE AND SPEECH.

1. Right cord lower than the left, with hyperkinetic dysphonia.
2. Right cord higher and broader than the left, with congenital dysphonia.
3. Hypoplasia of the left cord, with congenital dysphonia.
4. Congenital crossing of the arytenoids, with secondary laryngitis and congenital dysphonia.
5. Same with post-mutational falsetto voice.
6. Same with psychogenic hyperkinetic dysphonia.
7. Same with vocalis insufficiency and habitual mixed dysphonia.
8. Right ventricle of Morgagni wider than the left, with developmental hypokinetic dysphonia.
9. Right ventricle of Morgagni wider than the left, with psychogenic hypokinetic aphonia.

(soldiers) who were referred for disorders of voice or speech. These figures demonstrate again how statistics can be influenced by selective factors. It is obvious that cases of chronic hoarseness tend to concentrate in clinics for the special care of vocal disorders.

The vocal cord sulcus had been repeatedly noted by the older authors. Kelemen quoted the autoptic findings of Denker, Giacomini (1892), and Grabert (1914), who studied the larynx of the gorilla and of various human races. Salvi is usually credited with the first more complete description of the "sulcus vocalis" in 1901. Following the anthropologic ideas of his time, he considered the sulcus as a degenerative sign, allegedly more frequent among criminals. Other authors, like Alézais (1906, 1912), described the condition as "double vocal cords." In 1906 Citelli undertook more extensive re-

search and found further parallels in the comparative anatomy of animals. He coined the term "sulcus glottideus" and claimed to have found it in every second larynx dissected for this purpose. Sometimes the sulcus was barely visible with the naked eye. Further autopsy findings were reported by Hajek (1928), Demel (1928), Kelemen (1929), and by Frank and Malev (1939).

The first observation on a patient was made by Lautenschläger (1912). He also recognized that the hoarseness

Fig. 3. Congenital Asymmetry of the Larynx with Sulcus on Left Cord, and Hypoplasia of the Right Ventricular Fold.

was due to the incomplete closure of the glottis; therefore, he suggested that the insufficiency be corrected by the intralaryngeal injection of paraffin, according to the then new method of Brünings. In Oertel's case of 1912, an acute inflammation and swelling of the vocal cords temporarily improved the hoarseness which showed again that the dysphonia in a case of vocal cord sulcus was primarily due to the bowing glottis.

In 1928 Berger submitted the first phoniatric and stroboscopic analysis of the congenital dysplastic dysphonia due to vocal cord sulcus, or double vocal cords. Again, he noted the incomplete closure of the glottis. More cases were subsequently described by Van Caneghem (1928), Fornai (1936), Tarneaud (1944), or Delaini and De Stefani (1952). One

of their four cases showed hereditary tendencies. The largest number of cases was seen by Arnold who, in 1948, reported 12 observations. The combination with further laryngeal and oral anomalies in these cases is shown on Table II.

For a time some authors disagreed on the possible etiologic factors. Bilancioni observed in 1923 the development of a

TABLE II.

12 CASES OF VOCAL CORD SULCUS FOUND AMONG 1250 SOLDIERS SUFFERING FROM DISORDERS OF VOICE AND SPEECH.

1. Sulcus on right cord, prolapse of the left arytenoid, with congenital hypokinetic dysphonia.

2. Sulcus on both cords, hornlike elongation and phonatory crossing of both corniculate tubercles (similar to Blumenfeld's case reproduced by Beck and Schneider on their p. 429), absence of both cuneiform tubercles, with dysphonia ventricularis.

3. Sulcus on both cords, with habitual hyperkinetic dysphonia.

4. Sulcus on both cords, with congenital hypokinetic dysphonia.

5. Sulcus on both cords, with incomplete mutation of the voice, (developmental dysphonia).

6. Sulcus on both cords, with developmental dysphonia and dysphemia (stuttering).

7. Sulcus on left cord, with developmental dysphonia.

8. Sulcus on left cord, with habitual mixed dysphonia.

9. Sulcus on left cord deeper than the right, asymmetry of Morgagni's ventricles (the right wider than the left), vocalis insufficiency, with congenital hypokinetic dysphonia, and lisping (see Fig. 3).

10. Sulcus on left cord deeper than the right, contact ulcer right, vocalis insufficiency, anterior ventricular hyperkinesia, with congenital hypokinetic dysphonia.

11. Sulcus on left cord deeper than the right, palatal asymmetry, with developmental dysphonia.

12. Sulcus on left cord, with diphtheric vagus paralysis on the right.

tuberculous ulcer within a preexisting sulcus. Kelemen further quoted Spiess (1908), who saw the development of a longitudinal scar as a residue of a healed vocal cord gumma. Another opinion in favor of the tuberculous origin was voiced by Van Caneghem (1928), while Garel (1922) believed in a shrinking atrophy following chronic laryngitis. If one considers the frequency of tuberculosis, syphilis, or chronic laryngitis at the time of these observations, a coincidental combination of the congenital sulcus with such acquired granulations would not be surprising.

All recent authors are in accord with the original discoverers: that the vocal cord sulcus is a congenital malformation. Jackson and Jackson, who saw four cases of "supernumerary cords," called it a malformation of atavistic origin. Many authors referred to the normal presence of the sulcus in various animals, ascribing a regressive significance to its occurrence in man (Kelemen, Tarneaud, Delaini and De Stefani, etc.). The latest contribution to this interpretation was made by Sbernini in 1954. Evidence for the normal presence of a sulcus in animals can be found in the papers of Albrecht (1896), Wilson (1910), and particularly by Nemai (1912, 1926). The latter described double vocal cords, divided by a sulcus, in many species: deer, giraffe, antelope, swine, gibbon, etc. In accordance with previous authors, he found these accessory cords most noticeable in primates. It is interesting to note that he considered the development of these accessory cords below the true vocal cords of the gibbon as unfavorable for the vocal abilities of this species. According to Kelemen (1949) the reduplication of the vocal cords is particularly prominent in the chimpanzee larynx. He believes that the double cords are partly responsible for the double tones frequently heard in the voice of the chimpanzee.

SYMPTOMS OF DYSPLASTIC DYSPHONIA.

When listening to this type of voice, one is impressed by a peculiar hollow and unpleasant quality. It is difficult to describe it in words, but it reminds one of the sound made by a broken pot. It seems as though the two cords were out of tune. There is a constant breathy quality due to the excessive escape of air between the bowing cords. Hence, phonation time is short and the volume is weak. The average speaking pitch is often too high, apparently because the high tones are usually clearer. This is due to the bowing glottis, which is physiologic for the male falsetto tones, and, therefore, does not disturb the high tones as much as the low tones. Moreover, the patients tend to abuse their weak voices by faulty attempts at compensation. Instead of exploiting all reserves of projection and resonance, they try to overcome their disability by increased muscular efforts. This leads to various parakinesias, such as phonatory elevation of the larynx, over-

contraction of the external strap muscles, or constriction of the supraglottic resonance chambers. Habitual hyperkinetic disorders are thus superimposed on the congenital hypokinesis of the vocal cords, producing various combinations of vocal disfunction.

Treatment is rather difficult. Since the observations of Lautenschläger and Oertel it is well-known that the direct cause of the hoarseness consists of the hypoplasia of the vocalis muscles. Because these hypoplastic, asymmetrical, and possibly divided cords do not completely close on phonation, the voice is always accompanied by an escape of air. This addition of non-vibrating air to the voice sound is heard as hoarseness. Consequently, any surgical attempt at improvement would have to increase the closure of the glottis. I intend to follow Réthi's procedure, who corrected the state of myopathic paresis of the vocalis muscles by injecting vaseline into the bowing cords. The cartilage paste recommended in another publication (Arnold) for the compensation of adductor paralysis appears suitable also for a congenitally bowing cord. Messerklinger and Doubek described the successful correction of a bowing cord due to unilateral congenital sulcus by intra-cordal injection of paraffin by the Brünings method.

Vocal rehabilitation by appropriate voice therapy should always be tried. In any case one can improve the condition by eliminating the secondary parakinesias so that the patient may learn how to use his voice as well as his anatomical condition will permit. Unfortunately, it has to be admitted that the amount of progress is always limited. At the present time such voices cannot be greatly improved. It is, therefore, most important to advise these patients not to choose an occupation with heavy or specialized demands on the voice. Early recognition of the condition is the best service we can presently render to these patients. All authors share this prognostic reservation.

REPORT OF A CASE.

Case No. 71940, Pearl C., a white, unmarried female, age 18, was first seen on February 1, 1950. She complained of chronic hoarseness since earliest childhood. No other relative has any voice trouble. She

had always enjoyed good health and does not remember any unusual upper respiratory infections or allergies. Menstruation is uncomplicated and regular. Several previous examinations had reportedly been negative.

General appearance: A slender, asthenic, normally developed girl of good intelligence, with pleasant manners and an apparently calm temperament. No signs of emotional disturbance. No signs of anemia or other disease.

Nose and nasopharynx: The mucous membranes are unusually thin, pale and delicate. The turbinates are small and the passages open. No abnormal secretion, no respiratory obstruction.

Mouth: The lips, teeth, gums, tongue, and the palate appear normal. Tonsils are absent. The oral mucosa is unusually delicate and pale.

Ears and tubes: Very delicate membranes, no pathology.

Larynx: Small but symmetrical. All parts are very small and delicately built. The mucosa is thin and pale. Gross motility is normal. The vocal cords are white, thin and narrow; a longitudinal fine sulcus along the medial border of either side gives the impression of double vocal cords. The entrances to the ventricles are very wide. During phonation the bowing cords close incompletely, leaving an oval glottal chink wide open. The vibrations appear to take place between the lower segments of the cords.

Voice: Very hoarse, breathy and weak. Average speaking pitch between a-d^1 (220-294 cps.). Vocal range: g-c^2 (196-523 cps.), no differentiation of registers, the higher tones sound definitely better. Phonation time: Vowel O on tone c^1 7-8 sec. (normal: 20 sec.). Marked strain of the external laryngeal muscles is noticeable during phonation.

Speech: No noticeable disorder of articulation, diction, or sentence construction.

Diagnosis: Constitutional hypoplasia of all upper respiratory membranes; congenital bilateral sulcus with reduplication of vocal cords; congenital hypoplasia of the thyro-arytenoid muscles; dysplastic dysphonia, hypokinetic type.

Treatment advised: Attempt at vocal rehabilitation by improving resonance, projection, and enunciation, two sessions per week.

Progress notes: October 4, 1950: no change in objective findings, but patient believed to be considerably improved. December 13, 1950: subjective satisfaction continues. August 15, 1951: the voice continues to sound hoarse, breathy and shrill. October 29, 1951: no change in the bowing of the double cords. May 26, 1952: although the patient appears very satisfied, her voice is as hoarse, breathy and harsh as before. She left the hospital after having attended more than 200 therapy sessions.

In October, 1952, she was seen in Bellevue Hospital, where we made essentially the same findings and recommendations. Apparently the subjective improvement had not been permanent. In March, 1954, she appeared at the New York Eye and Ear Infirmary, where her congenital vocal disability was interpreted as "a hysterical speech defect."

Discharge summary: A case of congenital dysplastic dysphonia had been observed and treated for about four years. In accordance with all previous observations, no improvement could be achieved. An interesting feature in this case was the marked hypoplasia of all visible mucous membranes. Finally, the vibrations of the cords seemed to be concentrated on the lower portions of the double cords. In contradistinction, most of the previous observers had noted the vibration of the upper segments.

CONCLUSIONS.

The voice is an integral part of the human organs of communication. It represents the carrier wave on which are superimposed the modulations of the laryngeal voice sound by the articulatory movements of the speech organs. Serving this specific function, the voice should not be confounded with the other components of communication. The terms articulation, speech, and language, describe specific aspects of oral communication and cannot be used interchangeably.

Laryngeal pathology may disturb the voice in many ways. Contrary to the old idea of distinguishing organic and functional vocal disturbances, one now attempts an etiologic classification of the various dysphonias.

Dysplastic dysphonia refers to a group of chronic vocal disabilities due to minor anomalies of the larynx. They may be of hereditary, congenital, and connatal origin, or they may appear as a result of faulty laryngeal maturation during puberty.

The minor laryngeal malformations are characterized by great diversity. Their salient feature is an asymmetrical development of the two laryngeal halves, particularly of the vocal cords.

A special condition of congenital laryngeal anomaly appears in the form of the vocal cord sulcus. If deep enough, it creates the impression of reduplication of the cords. All recent authors regard this condition as a congenital anomaly of atavistic or regressive origin.

The symptoms of dysplastic dysphonia are well understood and do not present any diagnostic difficulties. Regrettably, the same cannot be said regarding treatment. One of our cases illustrates this general experience. In the future it will be worth while to apply the surgical principles of vocal cord injections. Favorable results were shown by Réthi (vaseline), Messerklinger and Doubek (paraffin), and Arnold (cartilage paste).

SUMMARY.

The well-known definitions of the various aspects of human oral communication are recalled. The basic function of communication is human phonation. It may be disturbed by many abnormal conditions, including congenital anomalies of the larynx. These malformations may affect all parts of the voice organs, and are particularly harmful to the voice if they disturb the symmetry and fine coordination of the vocal cords. One discrete cause of such dysplastic dysphonias is seen in the well-known condition of double vocal cords. This disability is described in detail and illustrated by a typical case.

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987 Fifth Avenue, New York 21, New York.

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POST GRADUATE COURSE IN RHINOPLASTY, RECONSTRUCTIVE SURGERY OF NASAL SEPTUM AND OTOPLASTY.

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AURAL-HARMONIC AND BONE-CONDUCTION THRESHOLDS IN THE EVALUATION OF COCHLEAR RESERVE IN CLINICAL OTOSCLEROSIS.*†

PHILLIP A. YANTIS, Ph.D.,
and
JOHN E. MAGIELSKI, M.D.,
Ann Arbor, Mich.

It has been generally accepted for some time that the prognosis for a significant improvement of hearing sensitivity due to operative intervention in the ear with a loss due to clinical otosclerosis depends to a great extent on the adequacy of cochlear function. The primary question to be answered by audiologic examination in these cases is this: Is the function of the cochlear structures sufficiently normal, as determined by pre-operative functional testing, that significant restoration of hearing sensitivity can be expected in the event of successful operative negation of the conductive impediment due to otosclerosis?

In attempting to test the adequacy of cochlear function, it is important to employ tests that will not be influenced significantly by any physiological abnormality of the middle ear. The most widely used procedure in developing an operative prognosis in these cases has been to compare the pure-tone thresholds obtained by air and by bone conduction, sometimes referred to as the "air-bone gap". A number of investigators have attached a great deal of importance to the bone threshold in relation to judging post-fenestration hearing sensitivity.

Shambaugh[1] suggested that those ears that are ideal for

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fenestration have a bone threshold within the normal range at 512, 1024, and 2048 cps. Those suitable but not ideal have abnormal bone-conduction sensitivity at 2048 cps., but normal thresholds at the other two frequencies. He classified those with a bone-conduction audiogram slightly below normal for two or all three of the above frequencies as having a limited and guarded prognosis. In a like manner, Kos and Reger[2] defined three classes of patients as determined by the relation between pre-operative bone and air thresholds. Those in Class I, with the best prognosis for improvement by fenestration surgery, show a bone acuity not exceeding an average loss of 15 db. for the frequencies 500, 1000 and 2000 cps. The second class of patients has an average bone acuity exceeding 20 db., but with at least a 30 db. gap in the three frequencies. The third class, and that group with the poorest prognosis, is made up of those with a bone acuity exceeding an average loss of 20 db. at the three frequencies. Shambaugh and Carhart[3] mentioned that an air-bone gap of less than 35 db. is a contraindication for fenestration. They believed that the ideal candidate has a maximum gap of 55 to 60 db. and a bone curve within 5 db. of the normal zero line.

Pick[4] recently listed what he thought are indications for stapes mobilization, and again the loss by bone conduction was emphasized, as well as the size of the air-bone gap; however, his indications for favorable prognosis were not as conservative as those proposed by other writers in relation to the fenestration procedure.

Personal observations of pre-operative bone-conduction sensitivity measures in otosclerotic ears, coupled with results obtained by other investigators, have led the authors to have certain reservations regarding the validity of air-bone comparisons alone in the judgment of cochlear reserve. It is the purpose of this paper to outline briefly the problems in bone-conduction technique and interpretation, and to discuss the application of a comparatively new technique to the evaluation of cochlear reserve: the aural-harmonic (aural-overload) test.*

*This technique has been referred to as both the "aural-harmonic" test[24,25,26] and the "aural-overload" test.[19,20,22] The former title is employed in this paper in order to promote consistency in terminology.

BONE-CONDUCTION TESTING.

Two of the important parameters in bone-conduction measurement are those of variations in the pressure of the vibrator against the skull, and individual differences in compliance of skin tissue between the vibrator and the mastoid process. Goodhill and Holcomb[5] found that even when the pressure of the receiver is constant at 400 grams, individual tissue variations may cause an error of 5 db. or more in sensitivity. They mentioned that bone-conduction results may be "contaminated" by such factors as air-borne sound being radiated by the bone-conduction unit, cartilage conduction from the vibrator to the tympanic membrane, and translational excitation of the ossicular chain due to inertia. Carhart[6] discussed other problems, such as faulty audiometer calibration, improper masking techniques, etc. At least some of these latter factors exist in any pure-tone audiometric situation, and can be effectively eliminated through careful precautions on the part of the examiner.

Even though the above criticisms are of importance, they are somewhat overshadowed by one particular phenomenon peculiar to bone-conduction testing in ears with stapes ankylosis. The restriction of stapedial motion relative to the skull seems to decrease substantially the bone-conduction sensitivity in the middle frequencies *in and of itself*, in many cases, even though the anatomic structure of the cochlea and its inherent physiological characteristics are apparently normal. This observation was noted by Smith[7] when he found such restrictions in a series of cats in which stapedial motion had been mechanically reduced. Mean sensitivity to bone-conduction stimulation was lowered 15 db. at 500 cps., 20 db. at 700 cps., 16 db. at 1000 cps., 9 db. at 1500 cps. and 4 db. at 2000 cps. after stapes fixation.

Various investigators have confirmed this phenomenon in pre- and post-operative examinations of a number of patients with otosclerosis. Table I shows the post-operative mean changes in bone-conduction thresholds in a total of 203 patients tested by six investigators. Woods[13] found that 90 per cent of 46 cases showed bone-conduction improvement

after fenestration and, in five other patients; he found an average increase of 14.2 db. in the speech frequencies.

On the basis of such evidence, Carhart[3,6] proposed that pre-operative bone-conduction thresholds may be corrected 5 db. at 512 cps., 10 db. at 1024 cps., 15 db. at 2048 cps. and 5 db. at 4096 cps., to predict post-operative bone-conduction sensitivity more accurately. Although this concept is important in emphasizing the changing character of bone-conduction sensitivity following surgery, the exact formula for each frequency cannot always be relied upon in an in-

TABLE I.

MEAN CHANGES IN BONE-CONDUCTION SENSITIVITY FOLLOWING FENESTRATION SURGERY IN A TOTAL OF 203 EARS.

Author	Reference No.	No. Ears	Bone-Conduction Improvement—Decibels 500 cps.	1000 cps.	2000 cps.	4000 cps.
Henner	8	72	2.5	8.7	8.2	7.5
Juers	9	28	3.0	4.2	13.0	
McConnell and Carhart	10	58	1.4	6.5	8.5	4.2
Nilsson	11	10	6.0	7.0	14.0	4.0
Söhoel*	12	35	15.0	12.0	11.0	–2.0

dividual case. This fact is amplified in studying not only the mean changes in bone conduction found by other investigators in terms of the apparent discrepancies in discrete thresholds from one group to another (see Table I), but, more significantly, in viewing the results obtained in individual cases. It is also necessary to keep in mind that Carhart's observations were made on ears that had undergone fenestration surgery. Because of the obvious differences in the concomitant anatomic and physiological characteristics of the middle ear following the fenestration operation, as compared to stapes mobilization surgery, it is apparent that complete reliance cannot be placed on the "otosclerotic notch" principle when stapes mobilization is the procedure of choice, until further research is conducted.

*The purpose of this recent investigation was to emphasize the changing character of bone sensitivity immediately following surgery. The thresholds quoted here were made three weeks post-operatively, and were of a stable character. The bone-conduction vibrator was applied to the forehead of all the patients tested in this particular study, and the ear not under test was masked.

Some of the physiological concepts that must be kept in mind in attempting to evaluate the bone threshold in losses due to otosclerosis will be reviewed and discussed later.

Because the accuracy of sensitivity thresholds made by bone conduction in the otosclerotic ear is at least questionable with respect to the judgment of cochlear reserve, bone-conduction sensitivity was compared with measurements obtained on the aural-harmonic test pre- and post-operatively. The latter procedure employs an entirely different physiological principle than does bone-conduction testing, and purports to be a direct measure of cochlear function.

THE AURAL-HARMONIC TEST.

The aural-harmonic (aural-overload) test is based on the observation that if a tone is presented to the ear at a sufficiently high intensity, the structures of the organ of Corti will not respond with normal fidelity.[15,16] This phenomenon is known as amplitude distortion or, more descriptively, aural overload. It has been found that not only is this distortion process a cochlear phenomenon,[17] but that, in the event the structures of the inner ear are damaged or are not functioning normally, the sensation level at which distortion begins to appear is lower than normal.[18,19,20,21,22,25,26]

To achieve the sensation level at which distortion occurs, some method must be employed by which the subject can communicate the emergence of this phenomenon to the examiner. This may be done by employing a variation of the classic exploring-tone method.[23] A pure tone (in this case 1000 or 2000 cps.) is introduced into the ear, and is gradually raised in intensity until distortion first appears. This tone is referred to as the fundamental. When distortion occurs, the amount of acoustic energy which cannot be linearly transmitted by the cochlear structures involved is converted into harmonics of the fundamental tone; however, the untrained subject usually cannot hear these harmonics in his own ear because of the comparative loudness of the fundamental tone. In consequence, the exploring-tone method is employed to enable the subject to report the presence of the harmonics in the form of a sensation of beats.

When a 1000 cps. fundamental tone is introduced into the ear, for example, an exploring tone of 2004 cps. is also led to the ear at an intensity level slightly less than the level of the fundamental. When the intensity of the fundamental is sufficiently high to produce aural distortion, the subject will hear four beats per second in the background of the funda-

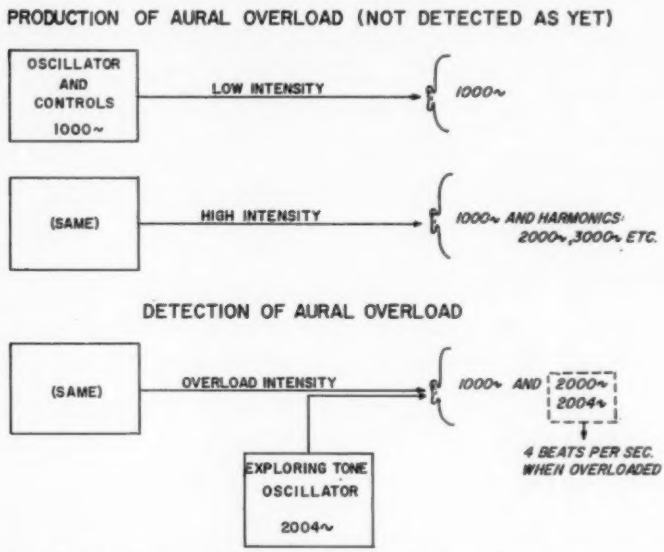


Fig. 1. Schematic diagram of the technique employed in detecting the aural-harmonic (aural-overload) threshold.

mental. These beats are produced through the interaction of the 2004 cps. exploring tone with the 2000 cps. second harmonic of the fundamental generated in the inner ear. When these beats are heard, the intensities of both the fundamental and the exploring tone are equally reduced until the subject no longer hears the beats. The intensity of the fundamental at which these beats are first detected is called the aural-harmonic, or aural-overload, threshold, and the number of decibels between sensitivity threshold and the detection threshold of the aural-harmonic is the linear range of hearing at

the particular fundamental frequency being tested. A simple illustration of the procedure involved in this test is given in Fig. 1.

Lawrence and Yantis[19] found, in over 130 normal ears, that the mean range at 1000 cps. was 52 db. and 57 db. at 2000 cps. Means obtained in abnormal ears were published in the last-cited study, but since that time a larger number of cases tested in this clinic have been added to the original data to give the mean values listed in Table II.*

TABLE II.

MEAN AURAL-HARMONIC THRESHOLDS OBTAINED IN NORMAL AND ABNORMAL EARS.

Category	No. Ears	1000 cps. Mean (db.)	1000 cps. Stand. Dev. (db.)	No. Ears	2000 cps. Mean (db.)	2000 cps. Stand. Dev. (db.)
Normal Ears	145	52	13	133	57	17
Middle-ear Pathology*	34	45	6	36	48	8
Cochlear Pathology	33	13	9	40	19	11

*These figures do not include the aural-harmonic data obtained in the ears reported in this study.

Three investigators, employing different fundamental and exploring-tone frequencies, have reported mean thresholds closely comparable to those of Lawrence and Yantis. Sokølowski,[24] using a 500 cps. fundamental tone applied by air conduction and a 1003 cps. exploring tone by bone conduction, found harmonic thresholds in normal ears from 45 to 50 db. above the fundamental-tone threshold. In losses of a conductive type, the threshold was essentially the same in sensation level; however, in perceptive losses with recruitment, Sokølowski found the aural-harmonic threshold to be only slightly higher than the intensity of the 500 cps. fundamental tone, providing the extent of the loss exceeded 45 to 50 db. Opheim and Flottorp,[25] using fundamental frequencies of 250 and 500 cps., found no difference between normal harmonic

*Through a mathematical error, the means and standard deviations of harmonic thresholds measured at 1000 cps. in the 17 ears with cochlear involvement were incorrectly stated in the article by Lawrence and Yantis,[19] and in the paper by Yantis.[20] In both of these publications, the mean range of linearity between audibility threshold and harmonic threshold was given as 24 db., and the standard deviation as 14 db. The correct calculations are a mean of 12 db. and a standard deviation of 7 db. This correction is incorporated in the data of Table II.

thresholds and those in ears with conductive losses, but markedly restricted ranges in 70 out of 73 ears with recruitment were recorded. They also found the test very helpful in the differential diagnosis of Ménière's disease.[26]

Since the aural-harmonic test employs the air-conduction pathway rather than the osseous route, it seems to be a measure of cochlear function not significantly influenced by the physiological status of the middle ear, and may hold some promise of being a comparatively *quantitative* measure of cochlear function. Accordingly, this procedure was compared with bone-conduction testing pre- and post-operatively with respect to the relative stability of the two tests under conditions of stapes ankylosis and improved hearing after surgical intervention.

PROCEDURE.

The nineteen patients tested in this study were examined in the Department of Otolaryngology, University Hospital. Each patient was given a complete pure-tone audiometric examination at least three times before the aural-harmonic test, with at least a one-month interval between each examination. The audiogram accepted as each patient's preoperative threshold pattern was an average of the three audiometric examinations conducted.

Pure-tone audiometric and aural-harmonic tests were repeated no less than one-and-one-half months post-operatively in those patients who submitted to fenestration surgery, and when necessary, after stapes mobilization. This was done to reduce to a minimum any possibility of the contamination of sensitivity measures by labyrinthine after-effects of surgery (see Söhoel[12]).

Pure-tone audiometric tests by air and bone conduction were carried out, using a calibrated Maico H-1 clinical audiometer. Traditional audiometric techniques were employed, including the use of masking when necessary. All tests on each subject were made with the same equipment and technique, and by the same examiner.

In attempting to reduce maximally the effects of the pos-

sible paramaters in bone-conduction technique outlined earlier, the following points were consistently followed in testing the patients used in this study:

1. Calibration of the bone-conduction vibrator was carried out, using Carhart's method of air and bone comparisons in normal ears and ears with a moderate pure perceptive loss.[6]

2. During all bone-conduction tests, the vibrator was held against the skull by a headband attached on the opposite side of the head to an earphone. The latter was placed over the external meatus of the ear not under test in all patients, whether masking was employed in the opposite ear or not. No means of keeping the pressure of the vibrator constant for all the ears tested was used, other than that of securing the vibrator as tightly as possible without causing pain or discomfort.

3. In all cases, the exact position of the vibrator post-auricularly was determined by ascertaining the best position to obtain the lowest sensitivity threshold for a 1000 cps. tone. The position decided upon was permanently used for all frequencies tested on any one ear. Repositioning was always carried out in subsequent sessions.

4. When masking was employed, careful attention was given to the intensity of the complex-noise masking signal to eliminate the possibility of trans-cranial conduction of the noise.

Aural-harmonic tests were carried out with carefully calibrated equipment especially designed for clinical use.* A detailed account of the original laboratory equipment used in previous experimentation is fully described elsewhere.[18,19] Very briefly, the technique employed in clinical testing was as follows:

1. The patient is instructed that he will hear a loud, steady

*For the harmonic-detection measurements made in this study, a clinical instrument designed and manufactured by Maico Electronics, Inc., was employed. The inherent distortion characteristics of the fundamental-tone oscillator were found to be very low; the second harmonic of the two fundamental tones was more than 60 db. below the acoustic level of the fundamental. This factor is, of course, extremely important in order to eliminate the possibility of intermodulation distortion occurring in the stimulus itself.[27]

tone, and that he should listen in the background of that tone for a wavy, or beating sensation. If he hears only a qualitative sensation of steadiness, he is asked to say "steady" after listening briefly to the tone. If he hears a beating sensation, he is requested to say "beat". Variations on this basic set of instructions are sometimes made if there is any doubt that the patient does not understand.

2. The fundamental tone (either 1000 or 2000 cps.) is then set to an entensity up to 70 db. above audibility threshold for that tone. The exploring-tone frequency is then made to differ from the second harmonic of the fundamental by approximately 4 cps., and is originally adjusted to be 10 db. below the intensity of the fundamental tone. These adjustments are made without stimulation of the ear under test.

3. The two tones are then mixed and presented to the ear being tested. In most cases the patient hears beats with only a slight adjustment of the exploring-tone intensity. If beats are not readily perceptible, then various techniques may be employed:

a. The levels of both tones may be raised equally.

b. The level of the exploring tone may be varied.

c. The exploring tone may be turned off and on for a short time.

d. Combinations of the above may be employed.

4. Upon hearing beats, the levels of both tones are commonly attenuated until the subject no longer hears the beats. If beats are still not heard after decreasing the level of the exploring tone, the level of the fundamental tone is recorded and considered to be the aural-harmonic threshold. The linear range is determined by substracting the audibility threshold for the fundamental tone from the intensity above normal audiometric zero at which the harmonic threshold was obtained.

5. The linear range is checked by carrying out the test from below the harmonic threshold previously obtained.

For the purposes of this study, a range from audibility

threshold to aural-harmonic threshold at either 1000 or 2000 cps. that is less than 35 db. (approximately one standard deviation from the mean in normal ears or in cases of conductive loss) is taken as indicative of abnormal cochlear function.

RESULTS.

The sex, age, ear operated upon and the type of operation performed are identified for each case in Table III. Ten

TABLE III.

IDENTIFYING DATA ON EACH OF THE NINETEEN PATIENTS (TWENTY EARS) TESTED.

Case No.	Sex	Age	Ear	Operation
1	F	28	Lt	Fenestration
2	M	29	Lt	Fenestration
3	M	52	Rt	Fenestration
4	F	21	Lt	Stapes Mobilization
5	F	41	Lt	Stapes Mobilization
6	F	29	Rt	Fenestration
7	F	34	Rt	Fenestration
8	F	35	Rt	Stapes Mobilization
9	M	52	Lt	Stapes Mobilization
10	M	31	Rt	Stapes Mobilization
11	F	29	Lt	Fenestration
12	F	52	Lt	Stapes Mobilization
13	F	43	Lt	Stapes Mobilization
14	M	39	Rt	Stapes Mobilization
			Lt	Stapes Mobilization
15	M	36	Rt	Stapes Mobilization
16	M	32	Rt	Stapes Mobilization
17	M	26	Lt	Stapes Mobilization
18	M	22	Rt	Fenestration
19	M	21	Rt	Stapes Mobilization

males and nine females were examined in this study; the age range was from 21 to 52 years, with a mean of 35 years. A total of 20 ears was tested, since Case 14 was operated upon bilaterally. Data were completely gathered on 19 ears at 1000 cps., and 17 ears at 2000 cps. Of the 20 ears tested, the fenestration operation was performed on seven and stapes mobilization was carried out on the remaining 13.

Group Observations. Because the aural-harmonic test was administered using fundamental tones of 1000 and 2000 cps.

only, Table IV presents the gross data for all measures taken on each of the subjects at these two frequencies only. The first group of seven cases are those on which the fenestration operation was performed, and the remaining cases submitted to the stapes-mobilization procedure. The means for the two separate groups, as well as the entire sample, are provided in the Table. The data obtained by air- and bone-conduction studies were eliminated for those ears in which aural-harmonic data were incomplete. Arithmetical calculations were carried to the nearest whole number.

Case 4, which will be examined in detail later, showed a marked decrease in air and bone sensitivity and in the harmonic threshold following surgery. Because there was reason to believe that the negative result was due to the operative procedure rather than to poor cochlear reserve pre-operatively, the data collected on this case were not used in calculating means.

Except for Case 4, every patient showed an improvement in air-conduction sensitivity at both frequencies in question, ranging from 5 to 40 db. (mean of 22 db.) at 1000 cps. and from 10 to 30 db. (mean of 19 db.) at 2000 cps.

Again excluding Case 4, bone-conduction sensitivity improved from 5 to 30 db. in 15 ears in the 1000 cps. column, and from 5 to 20 db. in 12 ears in the 2000 cps. column. The remaining showed no improvement in bone conduction, which was consistent at both frequencies for Case 10 and for Case 14 in the right ear. The mean improvement in bone conduction for all of the ears tested at 1000 cps. was 10 db. and 9 db. for those tested at 2000 cps.

All of the cases completely tested in this study had a pre-operative linear range of hearing of 35 db. or greater, meeting the requirements of normal cochlear reserve.

A discrete aural-harmonic threshold was not obtained in Case 17 at 1000 cps., and in Cases 11, 12 and 15 at 2000 cps. This was due to the intensity restrictions of the fundamental tone in the clinical equipment used. The maximum intensity available at either frequency was 100 db. *re* audiometric zero. In all of the cases in which pre-operative thresholds

TABLE IV.

THRESHOLD DATA OBTAINED IN EACH EAR COMPLETELY TESTED—IN DECIBELS.

		1000 cps.									2000 cps.								
		Air Conduction			Bone Conduction			Harmonic Thresh.			Air Conduction			Bone Conduction			Harmonic Thresh.		
	No.	Pre-op.	Post-op.	Chg.	Pre-op.	Post-op.	Chg.	Pre-op.	Post-op.	Chg.	Pre-op.	Post-op.	Chg.	Pre-op.	Post-op.	Chg.	Pre-op.	Post-op.	Chg.
FENESTRATION	1	50	25	25	20	15	5	40	50	10	50	25	25	10	5	5	45	50	5
	2	50	10	40	10	−10	20	50	55	5	50	25	25	15	−5	20	40	45	5
	3	50	45	5	15	10	5	45	40	−5	45	35	10	20	20	0	35	35	0
	6	40	20	20	15	−5	20	45	45	0	25	5	20	5	−5	10	50	45	−5
	7	50	25	25	10	−5	15	35	40	5	30	10	20	5	−10	15	65	60	−5
	11	60	30	30	25	−5	30	40	50	10	....	....	....	....	....	....	....	....	....
	18	35	5	30	15	0	15	40	40	0	35	10	25	5	−10	15	55	55	0
	Mean	48	23	25	16	0	16	43	46	3	39	18	21	10	−1	11	48	48	0
STAPES MOBILIZATION	4*	30	50	−20	5	15	−10	40	35	−5	30	55	−25	5	20	−15	40	30	−10
	5	25	15	10	10	0	10	50	50	0	35	25	10	30	15	15	50	50	0
	8	45	30	15	20	0	20	35	40	5	45	30	15	20	0	20	45	50	5
	9	55	35	20	15	10	5	35	30	−5	45	25	20	15	0	15	55	50	−5
	10	30	20	10	20	20	0	40	40	0	20	10	10	10	10	0	50	55	5
	12	40	10	30	−5	−10	5	45	45	0	....	....	....	....	....	....	....	....	....
	13	40	15	25	5	5	0	55	65	10	35	20	15	5	0	5	60	65	5
	14	40	10	30	5	5	0	50	50	0	25	15	10	−5	−5	0	65	55	−10
		35	0	35	10	0	10	55	55	0	25	0	25	−5	−5	0	55	55	0
	15	30	15	15	15	5	10	60	65	5	....	....	....	....	....	....	....	....	....
	16	45	25	20	15	5	10	40	45	5	40	25	15	10	0	10	45	45	0
	17	....	....	....	....	....	....	....	....	....	45	15	30	15	10	5	45	45	0
	19	25	5	20	10	5	5	55	55	0	30	0	30	15	0	15	55	55	0
	Mean*	37	16	21	11	4	7	47	49	2	35	17	18	11	3	8	53	53	0
	Total M*	41	19	22	13	3	10	45	48	3	36	17	19	11	2	9	51	51	0

*Results obtained in Case 4 were not included in the calculation of the sub-group or total mean data. See "Results" for the reason for this omission.

could not be obtained, this intensity was not sufficiently high to produce aural harmonics; however, in all of these ears, no evidence of amplitude distortion was detected at a sensation level of less than 50 db., thus connoting normal cochlear reserve under the terms of delineation accepted for this study.

The harmonic threshold at 1000 cps. changed post-operatively from a linear range that was 5 db. less than the pre-operative level to one that was 10 db. more than this intensity; at 2000 cps. the range was from 10 db. less to 5 db. more. Thus there was never more than a 10 db. change from the pre-operative to the post-operative linear range of hearing for any patient tested. Considering that there is at least a 5 db. error of measurement accepted in almost all clinical audiometry involving intensity increments of 5 db., this seems quite stable. The mean change was 3 db. at 1000 cps., and 0 db. at 2000 cps. In no case in which there was post-operative improvement in air conduction did the harmonic threshold decrease or increase post-operatively beyond one standard deviation from the normal mean as given in Table II.

Because of the comparative size of the samples, no attempt was made to compare the results statistically in terms of the two types of operations employed; however, it is interesting to note that the greatest mean improvement in air and bone conduction at 1000 cps. occurred in the "fenestrated" group (25 and 16 db. respectively, as compared with 21 and 7 db. for the "mobilized" group). At 2000 cps. there was also slightly more improvement in air conduction in the "fenestrated" group (21 db. compared to 18 db.) and in bone conduction (11 db. and 8 db. respectively).

Fig. 2 is a composite audiogram of the mean pre- and post-operative air and bone-conduction thresholds for the entire group. The mean harmonic thresholds are also provided. It is immediately apparent upon examining the changes occurring in hearing sensitivity for the three tests employed that there is a definite mean improvement in air and bone sensitivity for pure tones but, comparatively, an extremely small change, if any, in the linear range of hearing for the entire sample.

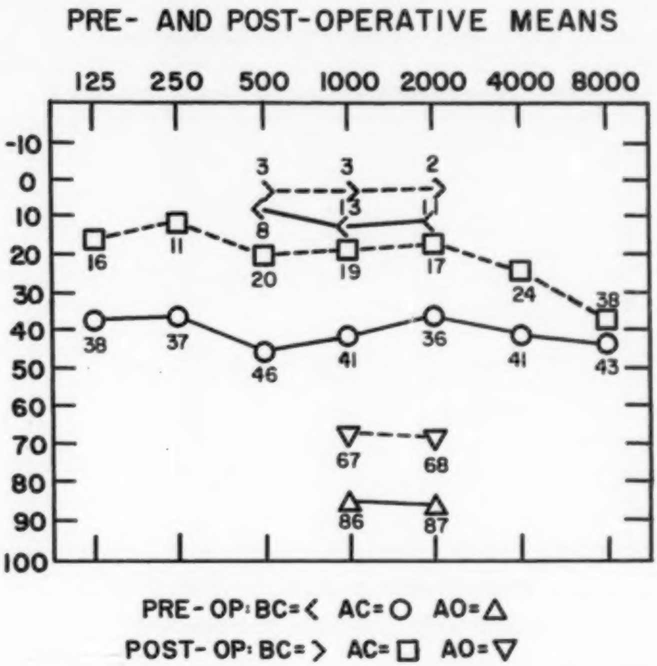
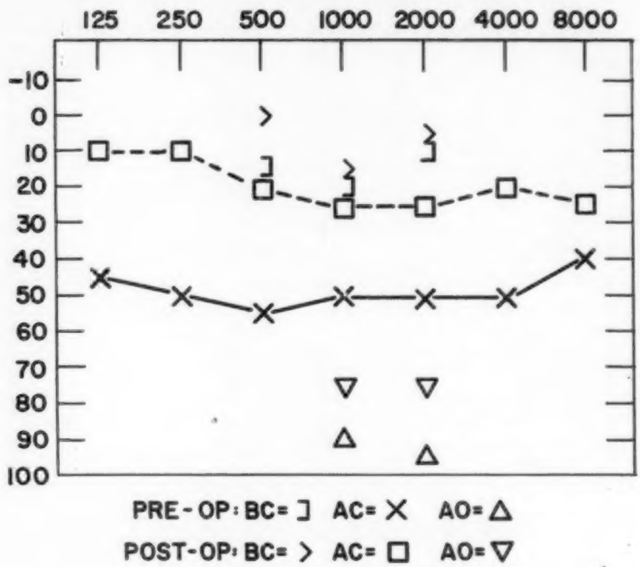


Fig. 2. Graphic representation of the mean pre- and postoperative thresholds for air conduction, bone conduction and aural-harmonics found in the ears in which all three tests were conducted in this study. The numerical mean thresholds are recorded. "AO" refers to the aural-harmonic (aural-overload) threshold.

Illustrative Cases. In order to demonstrate the particular types of problems and results that arise in individual cases and to illustrate the differences that can occur between patients, the results obtained in the first five ears tested are presented and discussed. The pre- and post-operative air, bone and harmonic thresholds *re* audiometric zero are presented in the figure referred to for each case.

Case No. 1. (see Fig. 3). Female, age 28 years. Left fenestration. The pre-operative air and bone sensitivity in this case presents a good prognosis for operative intervention. There is an air-bone gap of 30 db. at 1000 cps., and a gap of 40 db. at 2000 cps. A normal linear range from air-conduction threshold to the aural-harmonic threshold confirms the presence of good cochlear reserve.

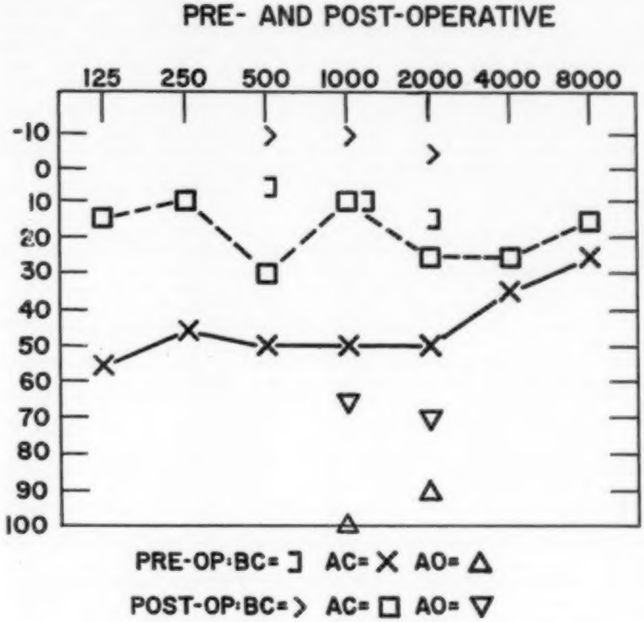
PRE- AND POST-OPERATIVE



AUDIOMETRIC DATA

FREQUENCY: 1000				2000		
TEST	PRE-OP	POST-	CHNG	PRE-OP	POST-	CHNG
A.C.	50	25	+25	50	25	+25
B.C.	20	15	+ 5	10	5	+ 5
A.O.	40	50	+10	45	50	+ 5

Fig. 3. Results obtained in Case No. 1.



AUDIOMETRIC DATA

FREQUENCY=	1000			2000		
TEST	PRE-OP	POST-	CHNG	PRE-OP	POST-	CHNG
A.C.	50	10	+40	50	25	+25
B.C.	10	-10	+20	15	-5	+20
A.O.	50	55	+5	40	45	+5

Fig. 4. Results obtained in Case No. 2.

Post-operatively, the good prognosis for air-conduction improvement is borne out by a significant rise in air-conduction sensitivity, providing socially adequate hearing in the operated ear; however, the expected improvement in bone conduction is not large, only 5 db. at the two frequencies of interest. Harmonic thresholds are improved slightly, and are still well within one standard deviation of the normal mean.

The important fact illustrated here is that, although in the large number of cases there is an expected improvement in bone sensitivity post-operatively, it cannot always be relied upon in individual cases. In this patient, there was enough of an air-bone gap to insure at least fair cochlear reserve, and the results of harmonic-threshold studies provided secure reinforcement of this conclusion.

Case No. 2. (see Fig. 4). Male, age 29 years. Left fenestration. The results obtained in this case illustrate quite remarkably the comparatively stable characteristic of the linear range of hearing after successful surgery, as opposed to a large change in bone-conduction sensitivity, and shows the "changing vs. stable" quality of the two tests that is generally found. It is evident that the pre-operative bone-conduction measurements were actually inaccurate to the extent of 20 db. at 1000 and 2000 cps., which is even a greater degree of inadequacy than could be accounted for by the application of the Carhart "notch" formula. Again, the possibility of good cochlear reserve was confirmed by a normal linear range of hearing.

Case No. 3. (see Fig. 5). Male, age 52 years. Right fenestration. At first examination, the data collected on this patient were almost identical before and after surgery, at least at the middle frequencies of interest in this study. On the basis of the pre-operative air and bone threshold alone, the prognosis would have been good, especially after applying the "notch" formula for bone-threshold corrections. Nothing abnormal was noted in the pre-operative aural-harmonic threshold at 1000 cps.; however, the linear range at 2000 cps. was comparatively restricted, and a guarded prognosis based upon selectively questionable cochlear reserve at 2000 cps. was made.

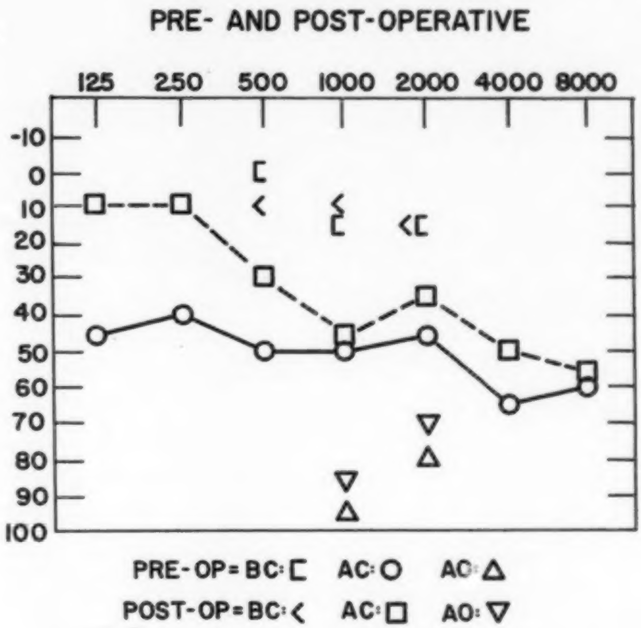
Because of the normal linear range at 1000 cps., surgery was carried out. Post-operatively, there was significant improvement in air-conduction sensitivity for the lower frequencies, but very little at 1000 cps. and 2000 cps. Bone conduction improved only 5 db. at 1000 cps., and remained stable at 2000 cps. The harmonic thresholds remained essentially the same.

In retrospect, it is assumed that the slightly restricted and unchanged linear range at 2000 cps. indicated localized cochlear pathology, at least involving the higher frequencies. This seems to be confirmed by the unchanged loss in bone sensitivity at 2000 cps. and the lack of improvement in air conduction post-operatively which is associated only with the higher frequencies.

Case No. 4. (see Fig. 6). Female, age 21 years. Left stapes mobilization. Although the outcome of surgery in this case was unfortunate, it is chosen to illustrate the use of the aural-harmonic test in determining the locus of damage in an unsuccessful procedure.

Pre-operatively, the test results were consistent with a diagnosis of good cochlear reserve and the prognosis for improvement was favorable.

Post-operatively, we find not only a decrease in air and bone sensitivity but, more significantly, a lowering of the linear range of hearing by 15 db. at 1000 cps. and 10 db. at 2000 cps. These post-operative measurements were made four months after surgery, and indicate a stable condition. These findings were interpreted as showing the presence of mild

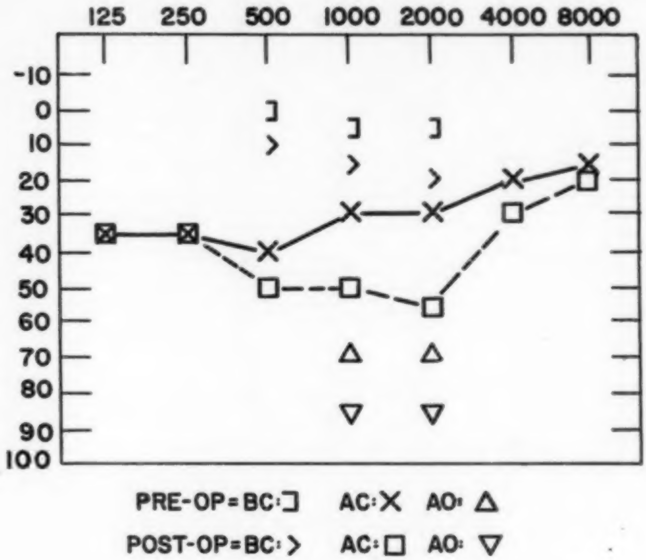


AUDIOMETRIC DATA

FREQUENCY:	1000			2000		
TEST	PRE-OP	POST-	CHNG	PRE-OP	POST-	CHNG
A.C.	50	45	+5	45	35	+10
B.C.	15	10	+5	20	20	0
A.O.	45	40	-5	35	35	0

Fig. 5. Results obtained in Case No. 3.

PRE- AND POST-OPERATIVE

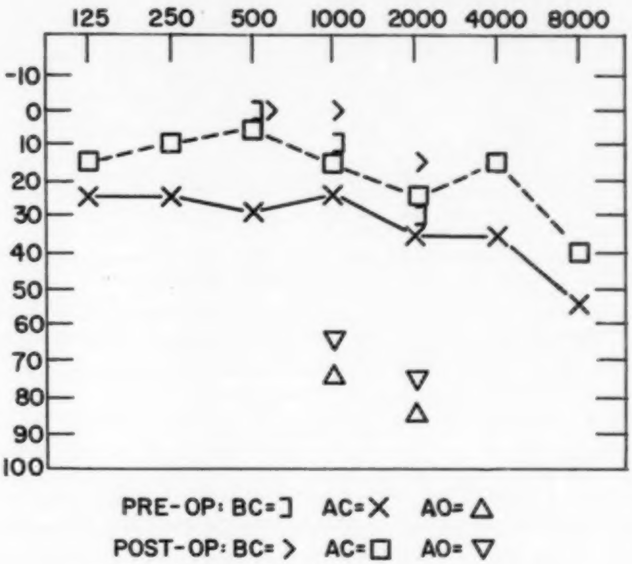


AUDIOMETRIC DATA

FREQUENCY:	1000			2000		
TEST	PRE-OP	POST-	CHNG	PRE-OP	POST-	CHNG
A.C.	30	50	-20	30	55	-25
B.C.	5	15	-10	5	20	-15
A.O	40	35	-5	40	30	-10

Fig. 6. Results obtained in Case No. 4.

PRE- AND POST-OPERATIVE



AUDIOMETRIC DATA

FREQUENCY:	1000			2000		
TEST	PRE-OP	POST-	CHNG	PRE-OP	POST-	CHNG
A.C.	25	15	+10	35	25	+10
B.C.	10	0	+10	30	15	+15
A.O.	50	50	0	50	50	0

Fig. 7. Results obtained in Case No. 5.

cochlear involvement of a permanent nature, most probably due to operative intervention; however, the conductive component is still quite large, and the patient may still profit by fenestration surgery.

Case No. 5. (see Fig. 7). Female, age 41. Left stapes mobilization. The pre-operative air-conduction threshold curve shows a moderate loss in the ear in question, but of a sufficient degree to lead the patient to seek medical treatment. The bone-conduction threshold is within normal limits for 500 and 1000 cps., but bone sensitivity is only 5 db. better than the air-conduction threshold at 2000 cps. On the basis of the audiogram alone, an interpretation of poor cochlear reserve involving the high frequencies could easily have been made; however, linearity measures at both 1000 and 2000 cps. were found to be normal, and mobilization of the stapes was carried out.

Post-operatively, the air-conduction curve is shifted upwards to fall within the normal range for most frequencies. Bone conduction is improved by 10 db. at 1000 cps. and 15 db. at 2000 cps. The level of the harmonic threshold remains unchanged.

This case illustrates at 2000 cps. how fallacious it can be to depend entirely on the "air-bone gap" for a discriminating evaluation of cochlear reserve. The pre-operative status of the cochlea for stimulation by a tone of 2000 cps. was inaccurately shown by bone measurement, as attested by a normal and unchanging linear range of hearing at this frequency, as well as a significant improvement in bone sensitivity at 2000 cps. after surgically reducing the degree of stapes ankylosis previously present.

DISCUSSION.

The general observation that bone-conduction sensitivity is improved after fenestration or stapes-mobilization surgery in the majority of cases of otosclerosis is confirmed in this study. It is safe to assume, on the basis of the evidence accumulated by the investigators dealing with this problem, that we cannot place complete reliance on the pre-operative bone-conduction threshold as an *accurate* indicator of true cochlear reserve in all of these patients. We also cannot expect a post-operative improvement in bone sensitivity of a certain pre-determined amount in the majority of individual cases. It seems reasonable to assume that the otosclerotic lesion, involving a reduction in movement of the footplate of the stapes, has a direct influence on the physiology of bone conduction, and that the removal of this condition, either by restoring stapes mobility or creating a labyrinthine fenestra, restores bone-conduction sensitivity to the level expected in the light of the existing cochlear function.

In attempting to explain the reasons for the general improvement of bone conduction after surgical intervention, let us review briefly the theory of cochlear stimulation by

osseous conduction and discuss the probable influence of otosclerotic pathology and surgery on the physiology of bone conduction.

The pathways of sound to the cochlea by bone conduction have been well defined by Guild,[28] and are familiar to all students of the hearing process. The osseous pathway, from the vibrator to the otic capsule directly through the bones of the skull, has been generally accepted as of much greater importance than the so-called osseo-tympanic route from the vibrator to the middle-ear cavity and thence to the round-window membrane.

The two modes of cochlear stimulation that have received maximum attention in the past are the translatory, or inertia, form of bone conduction, and the compressional mode. In translatory bone conduction, the contents of the cochlear capsule do not move in the same time relation with the bodily movement of the capsule itself. Because of the elastic qualities of the oval and round windows, the inertia of the cochlear fluids allows for a time lag in movement. Inertia opposing the vibratory force is also provided by the ossicular chain. When the labyrinthine capsule is placed into movement, the footplate of the stapes lags behind, due to the restraint on the stapes provided by the inertia of the ossicular chain. Thus, under these two conditions, the cochlear fluids are displaced relative to the capsular walls, providing concomitant displacement of the basilar membrane and resultant stimulation of the hair cells.

The compressional mode of bone conduction calls for periodic volume displacements of the cochlear fluids in direct relation to, and synchronous with, the periodic condensations and rarefactions of the stimulus sound. The theory implies that the entire labyrinthine capsule expands and contracts in response to stimulation, and that every portion of the capsular wall is vibrated with approximately the same force. A compression of the capsule would bulge out the round window due to fluid displacement, and a rarefaction would have the opposite influence on the membrane. In either case, resultant movements of the basilar membrane would produce neural stimulation.

The studies of Bárány,[29] Békésy[30] and Smith[7] all amplify the importance of the translational mode of stimulation. The compressional form is considered to be less significant and not affected to a great degree by stapes fixation.[17] Accepting this conclusion, we are led to the belief that in order to achieve adequate stimulation of the organ of Corti by bone-conducted sound, it is necessary to have at least two elastic membranes in the walls of the labyrinthine capsule in order to provide adequate mobility of the labyrinthine fluids with concomitant activation of neural impulses by hair-cell stimulation. When the impedance of the ossicular chain is increased by stapedial fixation due to otosclerosis, the normal translational mode of cochlear stimulation by bone-conduction is altered and, in the majority of cases, bone sensitivity is reduced. When normal mobility of the fluids is restored, either by restoration of stapedial vibration in the oval window or by the surgical provision of a new window in the horizontal semi-circular canal, an improvement in bone-conduction sensitivity is usually seen.

That certain changes in the status of the middle ear can influence the accuracy of bone sensitivity has also been borne out by studies involving conditions other than otosclerosis. Bárány[29] studied the effect of reduced middle-ear air pressure on bone-conduction sensitivity at 435 cps., and found that in the normal human ears examined, bone sensitivity was reduced approximately 10 db. under this condition. It could be hypothesized that the reduced air pressure in the tympanic cavity lowered the normal quality of mobility of the round-window membrane. Recently, Palva and Ojala,[31] after testing a series of 42 ears with catarrhal or purulent otitis media, in some of which bone conduction was improved after myringotomy, aspiration and subsequent healing, concluded that in certain cases of conductive-type hearing loss, the initially lowered bone-conduction threshold "does not necessarily indicate a perceptive involvement, but may be due to impaired mobility of the oval and round window."

Technically, there should be little difference between the stapes mobilization or fenestration procedures in the inherent quantitative restoration of bone sensitivity. In the former

technique, the original anatomic and physiological condition of the middle-ear structures are functionally restored. In the latter operation, although the transformer action of the ossicular chain is no longer present, there still is a sufficient difference in the phase relationships of the round window and the fenestra to insure adequate fluid mobility, providing the tympanic flap adequately isolates the round-window membrane.

As mentioned in the results of this study, it was found that there was a comparatively greater improvement in the mean air and bone thresholds in those ears that had undergone fenestration surgery. Except for the mean bone-conduction threshold at 2000 cps., the original extent of hearing loss was greater, on the average, in the "fenestrated" group; and yet at both frequencies post-operatively, there was a greater improvement in mean threshold in the latter group. These observations, though broad and inconclusive, lead one to speculate whether the formation of a new window, with relatively small inherent impedance characteristics as compared to the status of the normal oval window, produces better opportunities for more normal fluid mobility. The answer to this problem must, of course, await further exploration.

One important advantage of the aural-harmonic test, both physiologically and clinically, is its relatively stable characteristic under conditions of middle-ear pathology or surgical intervention. Although normal bone-conduction sensitivity depends to some extent on the relative normality of the middle ear, the process of recording amplitude distortion by the exploring-tone technique is not affected by any malfunction of the middle-ear mechanism. Normal measurements of linearity may be recorded even when the ossicular chain, down to the footplate of the stapes, is removed.[32] Thus, the critical factors of fluid mobility and general loss in air-conduction sensitivity affecting bone conduction have relatively no effect on distortion measurements using the exploring-tone technique. The fact that a quantitative threshold may be obtained by the aural-harmonic procedure connotes the possibility that a quantitative evaluation of cochlear function

may be determined. It is apparent that such a measure would be of great value in determining the efficacy of surgery, and it may have some importance in discerning the relative advantages of one operative technique over another in an individual case; however, until a much greater pathological sample is studied, we must be satisfied with the present use of the procedure in diagnostically delineating cochlear involvement.

In studying and endeavoring to interpret the means presented in Table IV, it must be emphasized that in the realm of operative prognosis in the patient with otosclerotic deafness we are concerned with discrete and individual anatomic, physiological and pathological problems that may vary remarkably with each patient encountered. Although the application of certain group measurements of auditory function to an individual case may be helpful in pointing out a general trend, they cannot be relied upon implicitly to give an accurate picture of future measurements. This is especially so after operative intervention with all of the concomitant parameters of technique involved, and unknown resultant changes in the physiological conduction of sound by the middle-ear mechanism in the case of the stapes-mobilization procedure. For example, in only one ear in this study (Case 5) were preoperative corrections of the bone-conduction curve, as determined by the "otosclerotic notch" principle, confirmed post-operatively. The primary importance of this principle is that it has brought to the attention of otologists the fact that a pre-operative bone-conduction audiogram obtained in an ear with otosclerosis is a relatively inaccurate indication of the actual capacity of the organ of Corti to be stimulated by sound conducted through the osseous pathway.

In being critical of group results obtained by bone-conduction testing, it would also seem consistent to be equally critical of group means obtained by the aural-harmonic test; however, it must be emphasized that a different physiological principle is involved in measuring cochlear distortion. We need not be concerned with the possible changes in the anatomical or physiological condition of the middle ear since any changes, even of a gross nature, have an insignificant

effect on the measurement of cochlear distortion in terms of sensation level. The studies of Wever, Bray, and Lawrence on animals,[17,32,33,34] and the results obtained in human ears such as tested in this study, substantiate this conclusion.

One main observation is emphasized: In the patients tested in this study, it was found that there is less change in the mean harmonic threshold post-operatively than in the mean bone-conduction threshold, and that in terms of accuracy and stability it is felt that more reliance can be placed on the aural-harmonic test as a direct measure of cochlear function. This observation seems of value in obtaining more consistent pre-operative measures of cochlear function in cases of clinical otosclerosis; however, of far greater importance, we feel, are the observations and interpretations made in the individual case with respect to variations and consistencies in the two techniques.

In conclusion, it seems somewhat fallacious in developing a prognosis for either fenestration or mobilization surgery to be satisfied with the principle of "closing the air-bone gap" as determined by pre-operative examination. It is certainly true that successful operative intervention will, in most cases, bring air-conduction sensitivity close to the pre-operative bone threshold; however, it is our belief that the otologic surgeon still has the responsibility of determining the condition of cochlear function as accurately as possible, before attempting to predict the effects of surgery in the individual case. The comparison of air- and bone-conduction sensitivity alone is not adequate in most cases. Qualitative judgments can be made with other tests, such as loudness-balance recruitment techniques, the discrimination score for speech, etc. Our experience with the aural-harmonic test as one of a battery of such procedures has been very helpful. The use of this technique as an actual quantitative measure of cochlear function has interesting potentialities, and the accumulation of data in a significantly large sample of otosclerotic ears is now being carried out in an attempt to determine the merit of this possibility.

SUMMARY.

Pertinent literature is reviewed, citing evidence for the post-operative improvement of bone-conduction sensitivity in the ear with a hearing loss due to clinical otosclerosis. It is emphasized that in most cases the measurement of bone-conduction thresholds in the ear with otosclerotic pathology may give an inaccurate picture of the true capability of the organ of Corti to respond to osseous stimulation.

The theory behind the aural-harmonic (aural-overload) test as a measure of cochlear function is briefly reviewed, and previous studies on human ears are discussed. In order to compare the relative stability of the two techniques (bone-conduction and harmonic measurements) in the evaluation of cochlear reserve, air-conduction, bone-conduction and aural-harmonic thresholds were obtained before and after either stapes mobilization or fenestration surgery in 19 patients with clinical otosclerosis. A total of 20 ears was examined.

It was found that at 1000 cps. there was a mean improvement of 22 db. for air conduction, 10 db. by bone conduction, and a mean change in the linear range of hearing of only 3 db. In the ears tested completely at 2000 cps., a mean improvement of 19 db. in the air-conduction threshold, a change of 9 db. in bone conduction, and no mean change in the harmonic threshold was found; thus, in this sample, the aural-harmonic test was found to be a more stable measure than the bone-conduction threshold. Five illustrative cases are presented and discussed.

The influences of stapes ankylosis and surgical intervention on the physiology of bone conduction are discussed. It is concluded that more reliance must be placed on audiometric techniques that are not influenced by anatomic and physiological changes in the middle ear in attempting to judge the status of the organ of Corti adequately. The aural-harmonic test, as one of a battery of such techniques, is proposed as an adjunct to a complete diagnostic evaluation of the patient with clinical otosclerosis.

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Department of Otolaryngology, University Hospital.

THE CONTROL OF ITCHING OF THE EXTERNAL EAR WITH SANDOSTENE.®

WALLACE RUBIN, M.D.,
and
JACK R. ANDERSON, M.D.,
New Orleans, La.

A number of investigators have reported the effective use of Sandostene® in relieving pruritis associated with a variety of allergic dermatologic conditions. This is a first report of the use of this preparation exclusively for the relief of pruritis associated with external ear conditions. We have evaluated Sandostene® in 147 cases of itching associated with pathology of the external ear. The control of itching has been dramatic, and the incidence of side effects has been minimal.

Sandostene® chemically is 1-Methyl-4-amino-N^1-phenyl-N^1-(2^1-thenyl) piperidine tartrate. The drug is commercially available as an enteric coated tablet, each tablet containing 25 milligrams of the active substance. Pharmacologically, Sandostene® has been shown to exhibit a variety of effects which would influence allergic processes. Its three physiologic actions, antipermeability, anticholonergic action and histamine antagonism make it ideally suited for the treatment of pruritis, as well as for controlling allergic responses.

The control of itching in the external ear is a most important therapeutic problem. The patient traumatizes the skin of his ear canal in an attempt to relieve the symptoms of itching, and in this way opens the pathway for infection. Scratching is an attempt to replace the burning, itching feeling with a less unpleasant sharper sticking but more painful sensation. The painful sticking sensation replaces the burning itching sensation even though itching fibers are still being stimulated. As soon as we stop scratching, the painful sensations of short duration cease, and the itching sensation again becomes pronounced. We then try to replace it with

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sticking pain by scratching, and the more we scratch the more after discharge of unpleasant itch occurs. The scratching traumatizes the ear canal, and in this way secondary infection can begin.

MATERIAL AND METHOD.

This study was based on observations made in 147 patients seen in private practice over a period of approximately one year. All complained of various degrees of itching associated with pathology of the external ear. In some cases the pathology was primary in the external ear, and in a number of cases the pathology was secondary to middle ear infections.

This study was designed to evaluate the symptomatic relief of itching and to determine whether the relief of itching influenced the length of time necessary to control the pathologic condition. We were interested in determining the most effective dosage of Sandostene® for controlling itching, and we were further interested in determining whether we could prevent external ear infections which were due to scratching the skin of the ear canal in an attempt to relieve itching.

DOSAGE.

Sandostene® in 25 mm. tablets, coated and uncoated, were available at various times during our study. Our dosage routine varied and was influenced by the response of the patient. In acute conditions where there was infection and marked itching, we started the patient on 50 mgm. Sandostene®, four times a day. When there was no relief with the first 24 hours, we instructed the patient to double the dosage so that the total dosage would reach 400 mgm. per day. In instances where there were side effects of drowsiness or nausea we instructed the patient to drop the dosage to 25 mgm. four times a day.

After a 72-hour-dosage schedule such as outlined above, the patients were instructed to cut the dosage of Sandostene® to either 25 or 50 mgm. as necessary for itching. In a small number of cases where the medication was used for children or in adults who could not easily swallow tablets, Sandostene®

syrup was used. There seemed to be no difference in the therapeutic effectiveness of the medication when used in the form of syrup.

Patients reported relief from itching in 20 to 30 minutes when Sandostene® was used. The duration of effect was very difficult to evaluate, as the medication was taken routinely at four hour intervals in acute cases. When the patients were on the PRN dosage schedule, they experienced relief from itching for as long as 24 to 48 hours. Obviously, this did not indicate a prolonged Sandostene® effect, but rather that itching did not recur.

TABLE I.

Diagnosis	No. of Patients	Dosage 200mg. per day	Dosage Other	Other Treatment	Relief of Itching Within 24 Hours Comp.	Part.	None	Side Effects Dry mouth	Nausea
Diffuse External Otitis	69	50	19	51	60	6	3	3	4
Eczematoid Ext. Otitis	33	26	7	24	27	3	3	2	4
Secondary External Otitis	9	8	1	9	2	4	3	1	0
Postoperative	6	5	1	6	0	3	3	1	0
Perforation	1	1	0	1	1	0	0	0	0
Chronic Otitis Media	2	2	0	2	1	1	0	0	0
Otomycosis	6	4	2	6	0	0	0	0	0
External Canal Pruritis (No Specific Etiology)	6	6	0	0	4	2	0	0	0
Circumscribed External Otitis	24	19	5	15	9	9	6	1	0

RESULTS.

The summary of findings are indicated in Table I. The summary indicates that the majority of cases treated were either diffuse external otitis or eczematoid external otitis. There was relief of itching in approximately 90 per cent of these cases within 48 hours. The majority of these cases were using other local and systemic medications to control the diffuse infection. In our experience only 30 per cent of patients are relieved of itching with the usual general or local therapeutic agents.

In the classifications of otomycosis and external otitis secondary to middle ear pathology the relief of pruritis was prompt and complete, regardless of the causative organism.

Of special interest to us were the cases in the category of external canal pruritis with no specific etiology. Here again there was complete relief of itching; this therapeutic response was not reproducible with any other medication.

The category in which the poorest results were obtained was in the circumscribed external otitis. Relief of itching was observed in only about 50 per cent of the cases, and this closely approximated the results obtained with other medications.

SAFETY.

The incidence of side effects was approximately 10 per cent. Nausea and marked dryness of the mouth were experienced, but neither were of particular consequence as they were relieved by cessation of the use of the medication. In all but two cases the patients were able to continue the use of the drug, as the side effects were so minimal in nature. In only two cases did the patients volunteer the symptom of nausea or dryness of the mouth. In the other 13 cases we had to elicit the symptom by direct questioning of the patients.

CONCLUSION.

In our series of 147 cases external canal pathology we have found that Sandostene® is an excellent therapeutic tool for the subjective relief of itching. It provided relief of itching in 90 per cent of the cases studied and is, therefore, an excellent adjunct medication in the treatment of external otitis. It is our belief that one of the primary factors in the pathophysiology of external canal infections, such as experienced in more humid climates, and infections associated with swimming, is that the patient responds to the itching of the ear canal by scratching. The trauma inflicted opens pathways of infection that were not present, and an ear canal infection ensues.

We have found that the use of Sandostene® for symptomatic relief of itching is extremely effective in preventing ear infections. Individuals who have considered themselves as having chronic ear infections have been amazed to find that

their flareups were few and far between when Sandostene® was used for the symptomatic control of itching. Preventing scratching and subsequent trauma of the skin of the ear canal maintains the pH of the skin of the ear canal and thus prevents the development of conditions conducive to infection.

SUMMARY.

1. 90 per cent of the patients treated obtained relief of pruritis, within the first 24 hours of Sandostene®, therapy.

2. We have found that 50 mgm. of Sandostene®, four times daily, is the preferred dosage for the first 72 hours; after that time dosage is altered to either 25 or 50 mgm. taken as necessary for itching.

3. We have further found that children can tolerate similar dosages either in the compressed tablet form or in the form of Sandostene® syrup.

4. Ten per cent of cases experienced side effects of either nausea or extremely dry mouth, but in all cases the side effects responded either to lowering the dosage or discontinuing the drug.

We have found no essential relationship between the cause of the external auditory pruritis and the ability of Sandostene® to provide relief of itching. We feel very strongly that Sandostene® is an excellent agent to be used for its antipruritic effect in external auditory canal pathology.

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*Sandostene® supplied by Sandoz Pharmaceuticals, Division of Sandoz Chemical Works, Inc., Route 10, Hanover, N. J.

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COURSE IN RECONSTRUCTIVE NASAL SURGERY.

The Department of Otolaryngology, University of Cincinnati College of Medicine, announces a Course in Reconstructive Surgery of the Nasal Septum and External Pyramid. The course will be under the direction of Dr. Maurice H. Cottle, Professor of Otolaryngology, Chicago Medical School, and a selected faculty, in association with the American Rhinologic Society, April 12 through April 19, 1958. Class membership limited. Tuition $350.00. Please apply to Dr. Henry M. Goodyear, Professor of Otolaryngology, College of Medicine, Eden and Bethesda Avenues, Cincinnati 19, Ohio.

THE 11TH CONGRESS OF THE INTERNATIONAL ASSOCIATION OF LOGOPEDICS AND PHONIATRICS.

The 11th Congress of the International Association of Logopedics and Phoniatrics will take place in London, August 17-22, 1959. The following official reports will be presented: The Inheritance of Voice and Speech Disorders, Prof. R. Luchsinger, M.D., Zürich; Defects of Articulation, Muriel Morley, B.Sc., F.C.S.T., Newcastle; The Physiology and Pathology of the Soft Palate, Prof. Lucio Croatto, M.D., Padua. The official languages of the Conference will be: English, French, and German.

Those working in the field of Speech and Voice Therapy and all who are interested in this specialty are invited to attend and to submit papers.

If intending to be present, whether submitting a paper or not, please inform the Congress Secretary at the earliest possible date.

Papers are invited on subjects relevant to the three main reports or any other aspect of speech and voice. Only one contribution will be accepted from any one member of the Congress and this must not have been previously published. The Committee reserves the right to select papers. Papers should be restricted to 15 minutes in length; demonstrations to 10 minutes. In special cases 20 minutes may be allowed for a paper of great importance but only if application is made at the time of submitting the title. Should a group of four or more people wish to present a symposium or a prepared discussion on a theme, consideration will be given to allocating up to one hour for such a contribution.

Titles must be received by September, 1958. Summaries must be received not later than November 15th, 1958.

All communications are to be sent to: Peggy Carter, L.C.S.T., 46 Canonbury Square, London, N. 1.

SUBCOMMITTEE ON HEARING IN CHILDREN.

The American Academy of Ophthalmology and Otolaryngology, through its Subcommittee on Hearing in Children of the Committee on Conservation of Hearing, has been conducting a long-term nationwide study of problems relating to the conservation of hearing in children. The specific aims are to develop the most efficient case-finding methods and to use these methods in estimating the magnitude of the problem in the country; to study state laws and review current practices and facilities for rehabilitation of hearing impaired children; to help develop methods for medical and surgical rehabilitation standards; and ultimately to use the Subcommittee findings in assisting professional workers to improve and enhance programs in hearing loss.

In the second year of operations, a full-time Executive Director has been engaged, and offices established at the Graduate School of Public Health, University of Pittsburgh. An initial study is being conducted in Pittsburgh to identify early medical signs and symptoms which may indicate danger of hearing impairment, to measure the psychological, social and other effects of such impairment and to develop efficient and economical methods for the testing of hearing in children. The Pittsburgh study is a cooperative effort among the following: The Subcommittee on Hearing in Children, the Graduate School of Public Health and the School of Medicine of the University of Pittsburgh, the Pittsburgh Board of Public Education, and the Allegheny County Department of Health.

The members of the Subcommittee on Hearing in Children are: Dr. John E. Bordley, Baltimore; Dr. Victor Goodhill, Los Angeles; Dr. Hollie E. McHugh, Montreal; Dr. S. Richard Silverman, St. Louis; and Dr. Raymond E. Jordan, (Chairman) Pittsburgh. An advisory committee of consultants from the University of Pittsburgh includes Dr. Samuel M. Wishik, Dr. Leo G. Doerfler, and Dr. Isidore Altman. Grants from the United States Children's Bureau through the Pennsylvania Department of Health and from the National Institutes of Health are providing financial support.

DIRECTORY OF OTOLARYNGOLOGIC SOCIETIES.

(Secretaries of the various societies are requested to keep this information up to date).

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Meeting: Palmer House, Chicago, Ill.

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Meeting: Palmer House, Chicago, Ill.

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Treasurer: Dr. Verling K. Hart, 106 W. 7th St., Charlotte, N. C.
Meeting: Mark Hopkins Hotel, San Francisco, Calif., May 21-23, 1958.

AMERICAN LARYNGOLOGICAL ASSOCIATION.

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Secretary: Dr. James H. Maxwell, University Hospital, Ann Arbor, Mich.
Place: Fairmont Hotel, San Francisco, Calif., May 19-20, 1958.

AMERICAN LARYNGOLOGICAL, RHINOLOGICAL AND OTOLOGICAL SOCIETY, INC.

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Place: Mark Hopkins Hotel, San Francisco, Calif., May 21-23, 1958.
Place: The Homstead, Hot Springs, Va., March, 1959.

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Place: The Homestead, Hot Springs, Va., 1959.

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Annual Meeting: October, 1958, Chicago, Ill. (Definite time and place to be announced later).

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Secretary of Otolaryngology Section: Dr. Robert W. Godwin.
Place: Los Angeles County Medical Association Bldg., 1925 Wilshire Blvd., Los Angeles, Calif.
Time: 6:30 P. M. last Monday of each month from September to June, inclusive—Otolaryngology Section. 6:30, first Thursday of each month from September to June, inclusive—Ophthalmology Section.

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Secretary-Treasurer: Dr. Arthur L. Juers, 611 Brown Bldg., Louisville, Ky.
Meeting: Palmer House, Chicago, Ill.

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY.

President: H. Leroy Goss, M.D., 620 Cobb Bldg., Seattle 1, Washington.
Secretary-Treasurer: Homer E. Smith, M.D., 508 East South Temple, Salt Lake City, Utah.
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President: Dr. Jose Gros, Havana, Cuba.
Executive Secretary: Dr. Chevalier L. Jackson, 3401 N. Broad St., Philadelphia 40, Pa., U. S. A.
Meeting: Sixth Pan American Congress of Oto-Rhino-Laryngology and Broncho-Esophagology.
Time and Place: Brazil, 1958.

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Ophthalmology: Dr. Warren A. Wilson, 1930 Wilshire Blvd., Los Angeles 57, Calif.
Mid-Winter Clinical Convention annually, the last two weeks in January at Los Angeles, Calif.

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